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Try It on Yourself

OFTEN *Power* publishes articles telling how practice has been improved and money saved by more or less simple changes in the constitution or management of a plant.

What succeeds in one case may not work in another; but do you try to apply their experience to your own job?

One man resets his boilers and gets along with considerably less coal. Why? Does he get better combustion or does he heat up less air than he used to, and send it up the chimney?

How about your own case? If some of these fellows are beating you, why is it? Poor coal, poor draft, poor firing, too little boiler capacity, too many boilers on at once, leaky settings, dirty boilers or what?

Here is a man who keeps track of the performance of his boilers and finds a surprising increase in their efficiency through regular and frequent cleaning. How often do you use a soot blower and a tube cleaner? What condition are your boilers in externally and internally? Do you know how much more steam you get per pound of coal when they have just been cleaned than you do some time after, how often it pays to clean them and what a dividend simple apparatus for doing this regularly and easily would pay upon its cost?

Here is a man who saved many times his own salary by using exhaust steam instead of running boilers purposely for heating and process work. How much chance does your case offer for doing the same thing?

There are a lot of little things that can be done about a plant to improve its economy without involving much expenditure. Do some of these and see that the boss knows about the results that you get. Perhaps he will gain confidence in your suggestions for more important improvements.

Stories are printed about antiquated plants that have been redesigned and reconstructed with modern equipment and modern practice. Is there spread enough between your present costs and the cost at which a modern plant can make power to make revision worth while?

If so, have you tried to make your employer see it?

F. R. Low

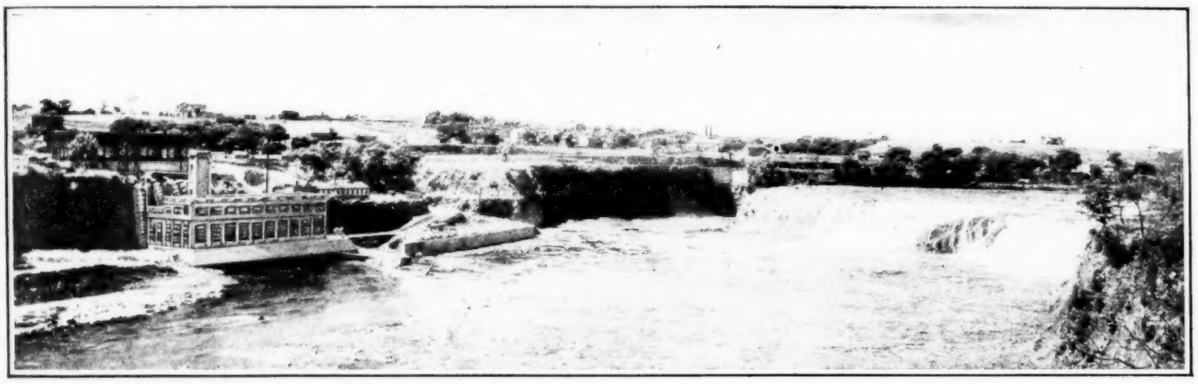


Fig. 1—Hydraulic canal runs from the forebay to one mile above the falls

Changing 10,000-Hp. Turbine Setting for Installing 16,000-Hp. Unit

By PAUL F. KRUSE*

IN THE School Street Station of the Cohoes Power & Light Corporation, Cohoes, New York, the setting intended for a 10,000-hp. hydraulic turbine has been modified to accommodate a 16,000-hp. unit and a 3.5 per cent increase in maximum efficiency attained. A large part of this improvement was due to changes in design of the draft tube.

USING the water of the Mohawk River for the development of power in the mills in the vicinity of Cohoes, near Albany, dates back nearly 100 years. Prior to the construction of the School Street Station of the Cohoes Power & Light Corporation, the water was used in five levels of canals, supplying low-head wheels of the many power users. To utilize the water efficiently under the total available head, the mills were provided with electric drive and the power for their operation was furnished from a single power station, which was designed and constructed in 1914 and 1915, by Sanderson & Porter. A masonry dam above Cohoes Falls diverts the water through a canal about one mile long to a forebay and gatehouse. From here it flows through steel penstocks to the power station, built at one side of the river channel. As originally planned and built, the station had space for five units rated at 10,000-hp. each, operating under a net head of 96 ft. The power house, gatehouse and water passages were completed for all five units, with the exception of two penstocks connecting the gatehouse with the power house and two scroll cases. Three of these units were installed at the time of the construction of the station. In 1921 a fourth unit, similar to the first three, was installed and put into service.

In the latter part of 1923 the engineers of the Cohoes company were instructed to proceed with the design and installation of the final unit in the station. At this time the load requirements and the characteristics of the system into which the station delivered its power had become such as to warrant the installation of a unit of greater capacity than that originally planned. It was desired to make the capacity of the new unit as much greater than that of the other units in the station as could be installed in the old setting without

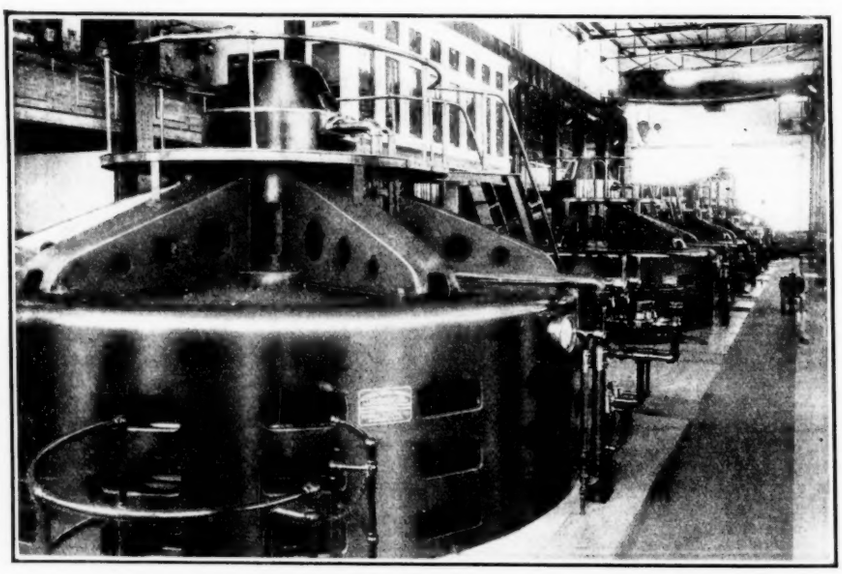


Fig. 2—Plant contains four 10,000- and one 16,000-hp. units

*With Sanderson & Porter, engineers, New York City

undue sacrifice of efficiency. The problem of increased size of the unit involved not only space limitations, but the use of certain parts of the water passages designed for a 10,000-hp. unit. These parts are:

1. A draft tube similar in dimensions and form to the draft tubes of the other four units in the station.

2. A turbine pit above the draft tube designed to accommodate a scroll case similar in size to units Nos. 1 to 4.

3. A section of plate-steel penstock 11 ft. in diameter and approximately 35 ft. long in the basement of the power house and extending through the rear wall.

4. An intake, formed in concrete in the gatehouse with a short length of plate-steel penstock, 11 ft. in diameter extending through the gatehouse wall.

Just what the conditions were in the power house before the new unit was installed can be seen by referring to Fig. 3. The short sections of 11-ft. diameter penstock, shown in full lines, in the gatehouse and power house were in place. A bent draft tube was formed in the concrete and is shown by the full lines. This draft tube extended only to the face of the power-house wall. The new draft tube, which is of a vertical flaring type with a special discharge, extends about eight feet beyond the power-house wall. The face of the piers extending out from the power-house foundations. To unwater the old setting, a steel and timber bulkhead was placed in the stop-log groove at the front of these piers and the water pumped out. To make the discharge of the draft tube longer than the present design would have required the construction of a cofferdam in the tailrace, the cost of which it was thought could not be justified by any slight gain in efficiency that might have been obtained.

In Fig. 4 it will be seen that the center line of the draft tube makes a small angle with the center line of the unit. This was done to avoid undercutting the

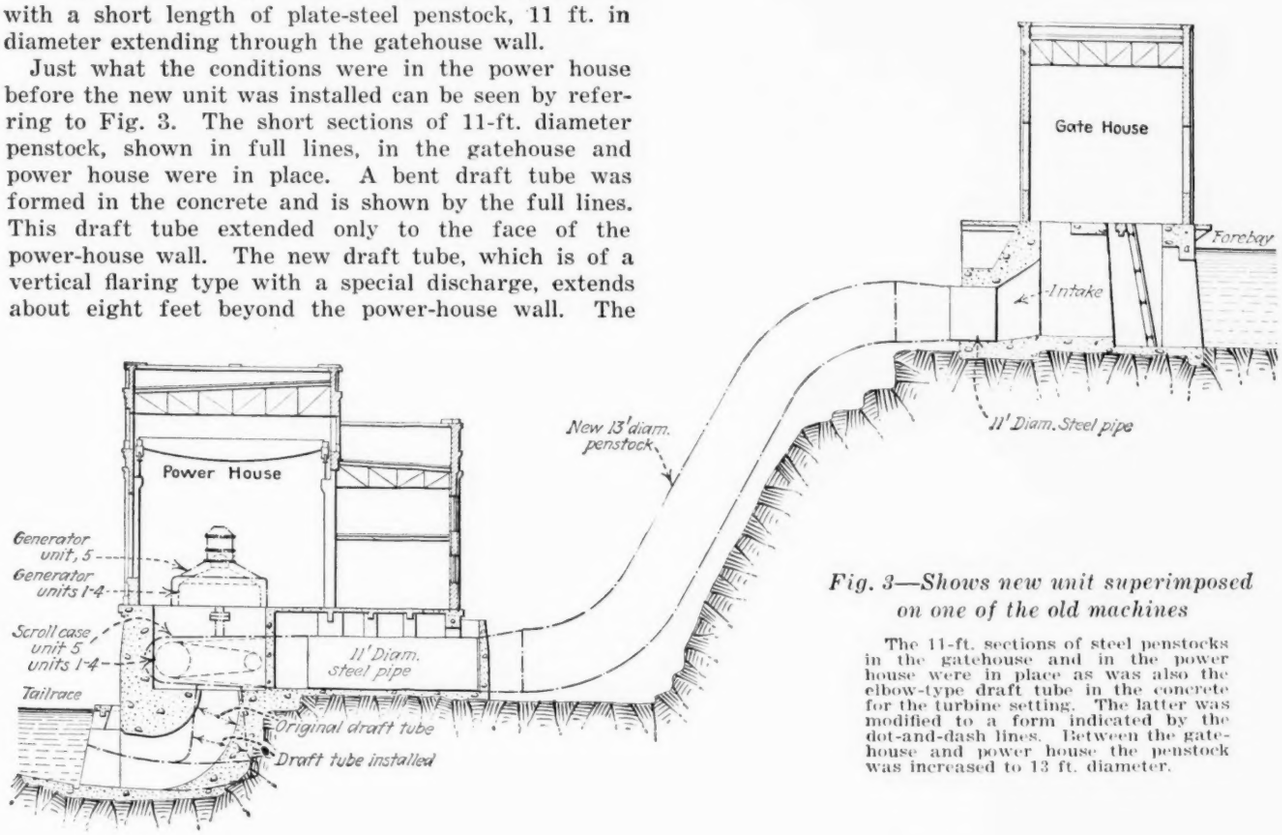


Fig. 3—Shows new unit superimposed on one of the old machines

The 11-ft. sections of steel penstocks in the gatehouse and in the power house were in place as was also the elbow-type draft tube in the concrete for the turbine setting. The latter was modified to a form indicated by the dot-and-dash lines. Between the gatehouse and power house the penstock was increased to 13 ft. diameter.

design of the new draft tube is shown in the plan and elevation in Fig. 4. It is also shown in dot-and-dash lines, superimposed upon the bent draft tube in Fig. 3.

It will be noted that the diameter of the new tube in its vertical portion increases slowly and at a constant rate for practically its whole length, when the rate of expansion increases rapidly and forms a sharp curve at the bottom of the tube. The chamber immediately below the vertical portion of the tube is designed for approximately constant velocity from the discharge of the bell to the throat of the horizontal portion of the tube. Instead of the floor of this chamber being flat, it is curved and, together with the side fillets, forms a banked surface around and beneath the periphery of the bell. The inclination of this surface increases rapidly toward the back of the tube as the angle through which the discharge from the bell must be turned increases. The roof of the discharge passage is also curved and forms a gradually increasing cross-section from the throat to the exit.

The new draft tube was extended approximately eight feet beyond the end of the old tube, to the end pier behind the bulkhead and to obtain the desired width for the draft tube.

Fig. 3 also shows the scroll case of unit No. 5 superimposed upon one of those used for units Nos. 1 to 4. It will be seen that the center line of the distributor is at the same elevation in both the old and new units, or about 9 ft. above normal tailwater level.

It was estimated that the canal had sufficient capacity to carry the water to the new unit without undue loss in head, but the penstock was enlarged between the 11-ft. sections in the gatehouse and power house to 13 ft., which amounted to about 40 per cent increase in cross-section. This arrangement has worked out very satisfactorily, as tests of the unit have shown a total over-all efficiency of about 87.5 per cent, including all the losses between the forebay and tailrace and the busbars. With a 14,300-hp. load on the new unit, which is the point of best efficiency, the water velocity in the 11-ft. section of the penstock is about 15 ft. per sec., and in the 13-ft. section about $10\frac{3}{4}$ ft. per second.

It was estimated in the preliminary study that by enlarging the turbine pit and modifying the draft tube,

the size of the unit could be increased 40 per cent over that of the first four units. The contract for the hydraulic equipment awarded to the turbine manufacturers was made on this basis with the provision that a series of tests were to be made to determine the best form of draft tubes to be used with existing conditions, and the efficiency and capacity that could be expected. In accordance with the policy of the power company in such development work, and with the co-operation of the manufacturing company, a unit was installed which not only gives 60 per cent increase in capacity instead of the guaranteed 40 per cent over that of an old unit, but also operates much more efficiently, the increase in efficiency at the point of maximum efficiency being approximately 3½ per cent.

The series of runner and draft tube tests referred to in the foregoing were conducted in the hydraulic laboratory of the manufacturing company, using a 16-in. model of the runner, proposed for unit No. 5, and various draft-tube models corresponding in dimensions to the test runner, including a model of the original tube and modifications of it.

Of the various designs of draft tubes tested, that shown in Fig. 4 was finally selected as being best adapted to the existing conditions when the efficiency and capacity of the unit and the cost of construction were considered.

Figs. 5 and 6 show a comparison of the results obtained with various draft-tube models in the laboratory and also a comparison of the laboratory tests with the type of draft tube installed and the field test with unit after installation. The model for test *A* conformed to the original draft-tube design, except that it had to be made relatively larger in the top portion to conform to the diameter required by the larger runner proposed for No. 5 unit.

Curves *A*, *B* and *C* show the actual efficiency obtained in the laboratory, but the values of power shown are those stepped up from the model to the full-size unit by the formula,

$$Hp. = hp. \times \left(\frac{H}{h}\right)^{3/2} \times \left(\frac{D}{d}\right)^{2}$$

where

$Hp.$ = Horsepower of full-size unit;
$hp.$ = Horsepower of the model;
H = Design head for full-size unit, equals 96 ft. net;
h = Operating head in laboratory (approximately 10 ft.);
D = Rated diameter of full-size runner;
d = Rated diameter of model runner.

A comparison of curves *A* and *B* shows the improvement that was obtained by modification of the original draft tube. Still greater improvement was obtained with the model of the draft tube installed, represented by curve *C*. With this draft tube the runner gave approximately 1¼ per cent greater efficiency and 10½ per cent greater power than with the model of the original draft tube.

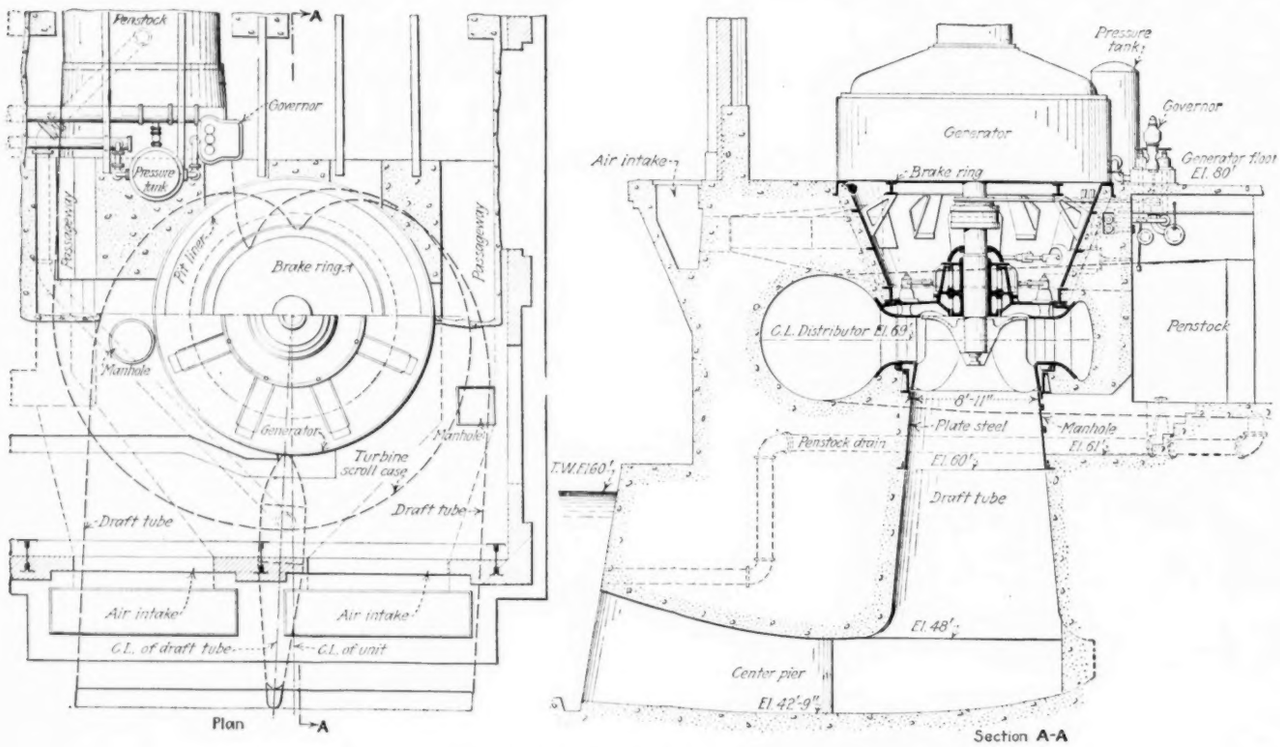


Fig. 4—Plan and elevation of new 16,000-hp. machine

As shown by the comparison of curves *C* and *D*, Fig. 5, and curves *C'* and *D'*, Fig. 6, the field test of the full-size unit shows a differential of approximately 4½ per cent higher efficiency than that obtained by the model apparatus in the laboratory. In the comparison of laboratory and field tests shown in curves *C'* and *D'* the curves are plotted on a basis of per cent of full load. The value of full load obtained from the model for determining curve *C'* was taken to correspond with the load at full-gate opening on the full-size unit. For example, in Fig. 6, 100 per cent full load, curve *C'*, corresponds to about 15,400 hp. in Fig. 5, whereas 100 per cent full load, curve *D'*, corresponds to about 16,950.

The foregoing was done on the assumption that the difference in efficiency between the full-size unit and the stepped-up model at full-gate opening was approximately the same as the difference in efficiency of the stepped-up model and that obtained by tests of the full-size unit at maximum efficiency. That is, the full-load point on curve *C* was obtained by taking a point *X*, 4.5 per cent below the full-load point on curve *D* and projecting a line horizontally to intersect curve *C*, as indicated in the figure. This gives a model full-load efficiency of 79 per cent, corresponding to 83.5 per cent for the full-size unit in the field tests. At these efficiencies the power, as shown on curve *C*, is 15,400 hp. and for the full-size unit approximately 16,950 hp.

DATA ON OLD AND NEW UNITS

	Unit Nos. 1 to 4	Unit No. 5
Rated horsepower	10,000	*16,000
Maximum	.....	16,950
Rated head, ft	96	96
R.p.m. of runner	185	150
Specific speed at rated load	61.6	63.2
Center line of distributor elevation	69	69
Bottom of draft tube elevation	42.75	42.75
Water velocities at rated load, ft. per sec:		
Entrance to penstock	3.9	6.0
Penstock between gate and power house	11.2	12.4
Penstock in power house	11.2	17.3
Penstock at entrance to scroll case	18.7	14.7
Vertical component at discharge from runner	26.1	26.3
At throat of draft tube	.....	11.6
At discharge end of draft tube	4.0	7.6

* New rating of 16,000 hp. taken at a point approximately 6 per cent below maximum load.

As a check on the foregoing, measurements were taken between all the gates of the full-size units, when set at full-gate opening, and an average width of gate opening thereby obtained. This field measurement for full-gate opening was found to be 10.74 in. and corresponded to a width of gate opening in the model of 1.62 in. The horsepower corresponding to this gate opening in the model apparatus, stepped up from the laboratory test to the full-size unit, was 15,590 hp. The average width of opening between turbine gates in the field, namely, 10.74, had to be determined with the penstock unwatered, therefore at the time the measurements were made the gates were not subject to unbalanced pressure as is the case under operating conditions. At full-gate opening, the balance of the gates is such that there is a slight tendency to close, thereby effecting a slightly smaller gate opening under operating conditions than that measured. For this reason the lower value of horsepower as given for the stepped-up models, namely, 15,400, was thought to be more nearly correct and was used for determining curve *C'*, Fig. 6.

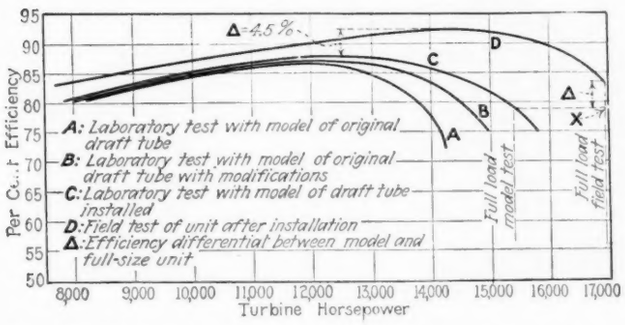

Δ-4.5%
A: Laboratory test with model of original draft tube
B: Laboratory test with model of original draft tube with modifications
C: Laboratory test with model of draft tube installed
D: Field test of unit after installation
Δ: Efficiency differential between model and full-size unit
Full load model test
Full load field test
Per Cent Efficiency
Turbine Horsepower

Fig. 5—Comparison of results obtained with different draft tube models and the field test

More complete utilization of the water of the Mohawk River for the development of electrical energy in the School Street Station of the Cohoes Power & Light Corporation has not alone been obtained by increasing the size and efficiency of the new unit, but also by operating the plant in accordance with a plan developed and put into service recently for directing the operation of the various units. This is based on efficiency tests made on the various units and will be described in another article.

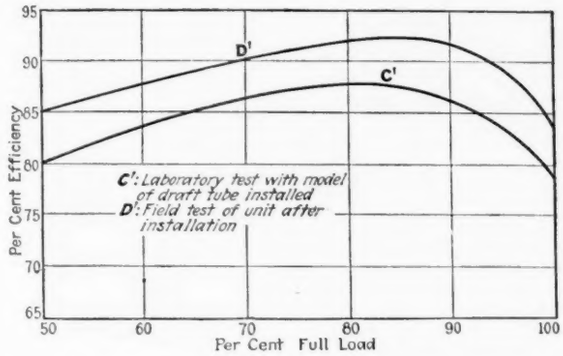

D'
C'
C': Laboratory test with model of draft tube installed
D': Field test of unit after installation
Per Cent Efficiency
Per Cent Full Load

Fig. 6—Comparison of stepped-up results from model tests and actual efficiency of unit after installation

The engineering and construction work for the installation of the fifth unit was done by Sanderson & Porter, of New York City. The waterwheel, governor and other hydraulic equipment, including the plate-steel scroll case and cast-iron turbine pit liner, were furnished by the S. Morgan Smith Company. The generator, exciter and other electrical apparatus were furnished by the General Electric Company.

Chattering of Brushes on Slip Rings

Brush troubles are generally associated with commutator-type machines. However, such troubles are not uncommon on the slip rings of induction motors and even on the field rings of synchronous machines. Chattering or sparking of the brushes on slip rings may be due to the angle of the brush, the brushes loose in the holders or the brush-holders too far away from the rings. It is the last that affects the angle of the brushes in many types of brush-holders.

Soft spots in the rings also cause chattering. In such cases the rings should be carefully ground to a true surface. Grinding is better than turning in a lathe, as a truer surface can be obtained, and on rings that are inclined to give trouble the truer surface they are given and the more accurately the brushes are fitted the less likely they are to give trouble. Where a motor is started under a very heavy load, the current flowing from the brushes to the rings may be sufficient to cause burning of the surface of the ring unless the brushes are liberally proportioned and accurately fitted. Other causes of chattering are worn shafts or bearings on a sprung shaft.

If the machine is inclined to be sensitive at the brushes, any defect that might cause radial movement of the brushes should be removed. If the shunts that connect the brushes to the holders become loose, the springs may carry sufficient current to overheat them and destroy their temper, a condition that must be remedied before satisfactory operation can be obtained.

Sidelights on Scale and Corrosion

How Calcium Sulphate Crystals Entangle Calcium Carbonate—Simple Experiment Shows Effectiveness of Sodium Hydroxide in Preventing Corrosion

IN THE February 2 issue of *Power* was an abstract of the article, "Boiler Water Conditioning With Special Reference to High Operating Pressure and Corrosion," which R. E. Hall delivered before the recent Midwest Power Conference in Chicago. The abstract contained the gist of Dr. Hall's paper. At the same time it was necessary, for lack of space, to omit certain sidelights of much interest. One of these was a demonstration of the way in which scales of various composition form. The other was a simple experiment that anyone can repeat to demonstrate the effect of sodium hydroxide upon corrosion.

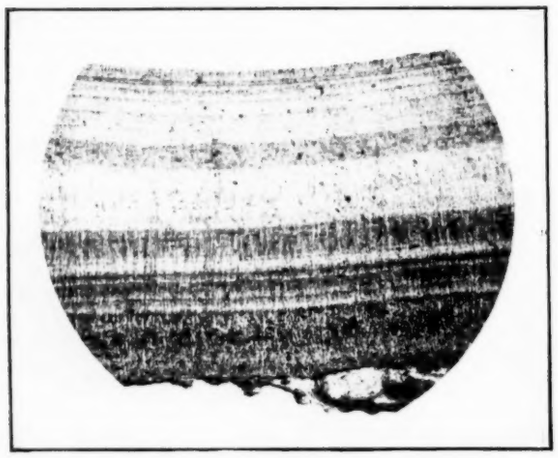


Fig. 1—Microphotograph of a slice through calcium-sulphate scale showing layers of crystals

Calcium carbonate does not crystallize on metal surfaces in this manner.

The photographs shown herewith are from Doctor Hall's paper, and the following comments are based on information given in his paper.

Adherent scales that grow in thickness are formed by deposition from the boiler water directly upon the surfaces where they are found when the boiler is opened. Fig. 1 is a microphotograph of a slice taken through calcium-sulphate scale. Each layer is seen to consist of many crystals, the axes of all the crystals being at right angles to the layers. Three substances deposit from boiler water in this manner—calcium sulphate, calcium silicate and magnesium silicate.

Calcium carbonate by itself will not form this kind of scale. It can, however, become part of a scale when loose crystals of calcium carbonate become entangled in a matrix of one or more of the three substances mentioned. Thus, in Fig. 2 the framework of the scale is evidently the large interlocking crystals of calcium sulphate, while in the interstices are found magnesium silicate and calcium carbonate.

Turning now to the question of corrosion, it can be demonstrated that where two strips of boiler steel are immersed in water containing some electrolyte, such as sodium sulphate, and where the water touching one strip of steel contains more dissolved oxygen than that touching the other, the whole affair will act like a battery if the two strips are joined by a copper wire. In this case the strip at which the oxygen concentration is smaller is the anode, that is, the current flows through the solution from that strip to the other, then out and back through the external conductor to the first strip. The anode loses weight by corrosion in proportion to the amount of current developed.

This action has been demonstrated by a simple experiment that one can repeat without special apparatus. Figs. 3, 4, 5 and 6 show four stages of the experiment. Four strips of cleaned boiler steel (marked *a*, *b*, *c* and *d*) were taken. Near the upper end of *a* was placed a little puddle of distilled water; on *b* water containing sodium sulphate only, on *c* water containing common salt (sodium chloride) only, and on *d* water containing both sodium sulphate and sodium chloride. On the lower ends of the same strips were placed drops of exactly the same composition except that sodium hydroxide had been added in each case. The concentrations of these various salts in parts per million are given in the accompanying table.

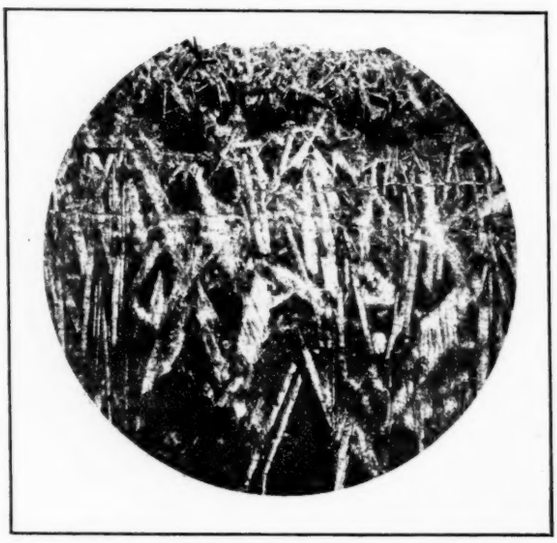


Fig. 2—Microphotograph of scale consisting of calcium carbonate and magnesium silicate entangled in a matrix of calcium sulphate crystals

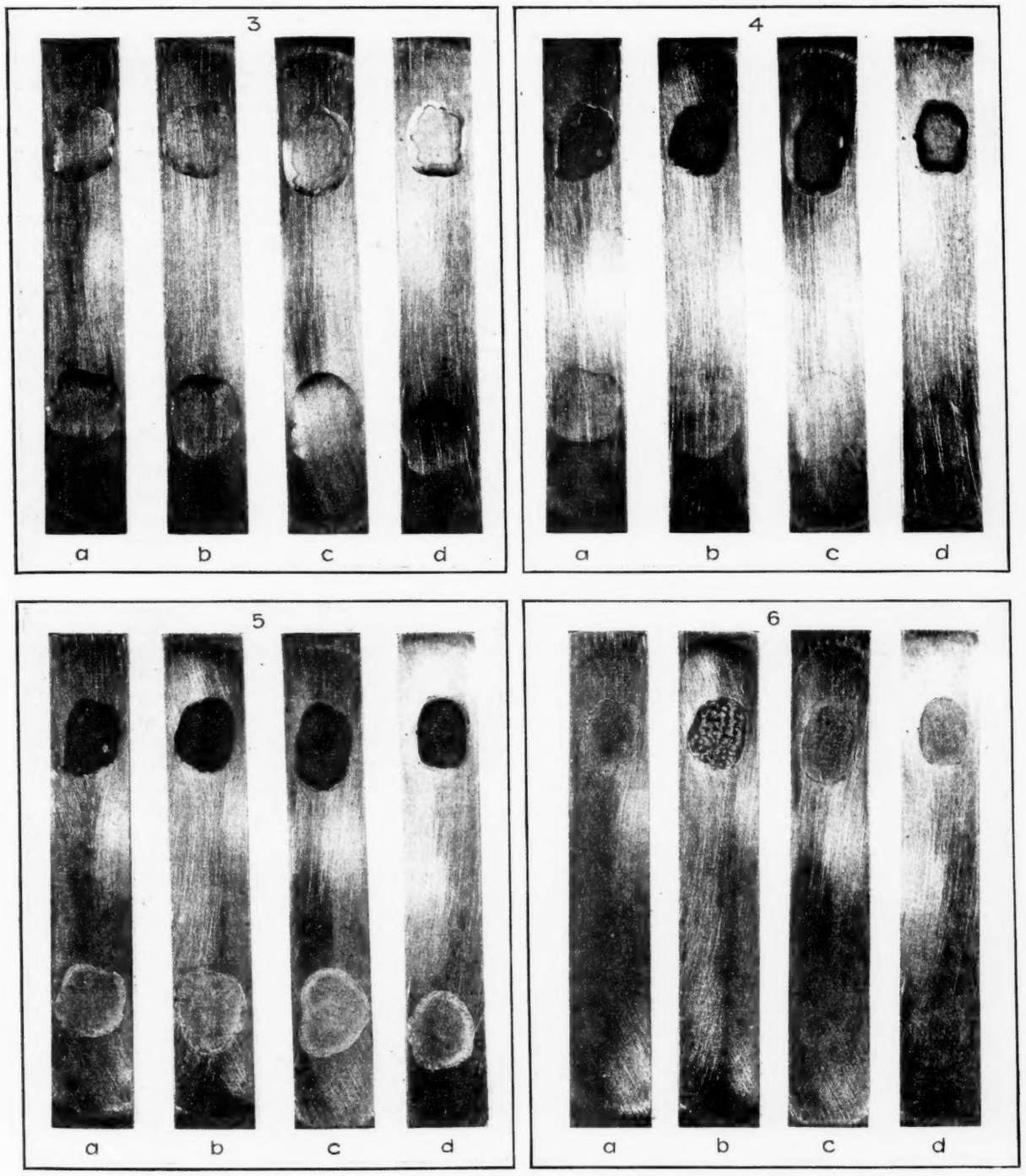
Fig. 3 was photographed five minutes after the drops were placed in position, Fig. 4 after 27 minutes and Fig. 5 after 70 minutes.

In Fig. 3 corrosion is already noticeable under each drop of the upper row. In Fig. 4 it is pronounced. In Fig. 5 all the liquids have dried up, leaving the stains of the corrosion products in the upper row and the evaporated salts in the lower. That this is actually the case is shown by Fig. 6, this photograph being taken

after the strips had been wiped off with a damp rag, removing any soluble salts.

The practical conclusion to be drawn from this experiment is that distilled water, water containing sodium sulphate, water containing sodium chloride (common salt) alone, or water containing both of these, is corrosive on boiler steel, at least under ordinary atmospheric conditions, and that the addition of a certain amount of sodium hydroxide practically prevents this corrosion.

The explanation of this phenomenon as given by Doctor Hall is rather interesting. It is as follows: When the drops are first placed on the metal, any dissolved oxygen is uniformly distributed through them. In contact with the metal, however, this oxygen, which is necessarily small in amount and negligible in its effect on the metal surface, unites with it. On the exterior surface of the drop the air in contact furnishes a supply of oxygen, and the concentration of that in the solution does not diminish materially. In the interior, however,



Figs. 3-6—Simple experiment demonstrates action of sodium hydroxide in preventing corrosion of boiler steel

Top row of drops: *a*, distilled water; *b*, solution of sodium sulphate; *c*, solution of sodium chloride (common salt); *d*, solution of sodium sulphate and sodium chloride. Bottom row of drops same as upper except that sodium hydroxide has been added. All upper drops show rapid corrosion, while practically none is produced by lower drops. Pictures taken as follows: Fig. 3, 5 min.; Fig. 4, 27 min.; Fig. 5, 70 min.; Fig. 6, after wiping with damp rag.

this is not the case, and a deficiency in oxygen exists. Thus a condition has developed which is precisely that of the electrolytic cell previously described. The metal in contact with the interior portion of the drop becomes an anode and starts to dissolve (corrode). The exterior portion, with more oxygen, forms the cathode and hence does not dissolve. Careful inspection of the photographs shows that the corroded area is a little smaller than the drop. Attention should be called to the fact that the electrical circuit is completed through the body of the metal.

Now why is it that the lower row of drops, where there existed exactly the same opportunity for differences in oxygen concentration, produced no appreciable corrosion? Since conditions in the lower row were identical with those in the upper row, except for the presence of sodium hydroxide, it is reasonable to conclude that sodium hydroxide is a specific preventive of corrosion under the given conditions. It is Doctor Hall's belief, based on experimental work, that the hydroxide prevents corrosion by discharging at the anodes some component in the boiler water, this taking the place of the anode metal which would ordinarily be dissolved.

COMPOSITION OF SOLUTIONS (PARTS PER MILLION)

	Strip 1	Strip 2	Strip 3	Strip 4
Upper Row of Drops				
Sodium sulphate	0	740	0	370
Sodium chloride	0	0	825	412
Sodium hydroxide	0	0	0	0
Lower Row of Drops				
Sodium sulphate	0	740	0	370
Sodium chloride	0	0	825	412
Sodium hydroxide	1,175	1,175	1,175	1,175

Synchronous Converters Versus Motor Generators

By C. O. MILLS

WHERE alternating current is available and direct current is required for power purposes, means must be provided for converting the alternating into direct current. Either one of two classes of converting equipment is generally used—namely, synchronous converters, or, as they are frequently referred to, rotary converters; and motor-generator sets. The latter usually consist of a synchronous motor driving a direct-current generator, and are the class of equipment considered in this discussion. Small size motor generators for converting alternating current into direct current usually consist of an induction motor driving a direct-current generator. Where the synchronous motor can be applied economically, it should be used, as it has superior power-factor characteristics compared with those of the induction motor. Although synchronous motors are available in sizes down to 20 hp. for driving slow-speed compressors, 50 hp. is about the economic limit for motor-generator sets. For the smaller sizes, rotary converters may be used, but there are a number of factors that are against them competing with motor-generator sets.

Which is the more economical to use, synchronous converters or motor-generator sets, for converting alternating into direct current for industrial loads is a question about which there has been a great deal of discussion. The motor-generator set can be used in any installation, but there are conditions that preclude the use of synchronous converters. If the converting equipment is to operate in parallel with direct-current generators driven by waterwheels, engines or other types of prime movers, more satisfactory operation will be obtained with motor-generator sets than with rotary converters. Any voltage fluctuations in the alternating-current supply are reflected through the converter to the direct-current side.

Where it is desired to use the machine for power-factor correction as well as for converting from alternating to direct current, the motor-generator set should be used, as the converter is not well adapted to such applications. Rotary converters are usually designed to have a power factor near unity, for loads from 75 to 100 per cent of their rating. Below 75 per cent load the power factor falls off quite rapidly, being about 0.90 at 50 per cent load, 0.50 at 25 per cent load and 0.20 lagging at no load. With motor-generator sets the power factor can be made unity at full load and leading at all other loads if the field current is allowed to remain constant. Or the set may be equipped with an 80 per cent power-factor motor, in which case the power factor will be 0.80, leading at full load and operate at lower leading power factors at part loads.

Value of Power-Factor Correction

The value of power-factor correction depends to a degree upon the conditions. If power was being purchased on a contract that included a power-factor clause, the power-factor-correcting characteristics of the motor-generator set would have greater economic value than where such a clause was not in the contract. In the case of industrial plants where the power factor is low, the installation of the motor-generator set not only will materially improve the power factor but also may make available feeder and generator capacity for other purposes and improve the voltage regulation. These factors should be considered in the comparison of the two machines. The motor-generator set under any conditions will improve the power factor, whereas the rotary converter will do this at near full load only.

Considered as individual equipment, the rotary converter has an advantage of about 5 per cent in efficiency over the motor-generator set. This factor, however, should include the improvement in system efficiency due to the power-factor correction of the motor-generator set. On a system where the power factor is low lagging, the improvements due to putting a synchronous motor of proper design on the system may outweigh any advantages in efficiency claimed for the rotary converter. In addition, as has already been pointed out, generator and feeder capacity may be made available.

Other factors that have a bearing on the problem are control of the direct-current voltage, cost of the equipment and the space required for the installation. In the motor-generator set, the direct-current voltage is independent of the voltage of the alternating-current supply, therefore one is not affected by the other and the direct-current voltage is more readily controlled than on a synchronous converter. In general a rotary converter with its auxiliary equipment will cost about 10 per cent less per kilowatt capacity than a motor-generator set with its auxiliary equipment. The rotary converter with its transformers will generally require from 10 to 25 per cent more floor space than a motor-generator set of equal capacity. The low figure is for large machines.

Alternating-Current Motors—Fundamental Principles

By B. A. BRIGGS

THIS article is the first of a number dealing with alternating-current motors. The construction of the direct-current and that of alternating-current machines are compared, how a rotating magnetic field is produced, and such features as slip, pull-out torque and the induction generator are explained.

ALTERNATING-CURRENT motors are built in a great variety of forms to meet the need of the many conditions in industries. The simplest of these types is that known as the squirrel-cage. The stationary element of such a motor would generally have a distributed winding similar to that shown in Fig. 1. This part corresponds to the field structure in a direct-current machine, Fig. 3, but instead of the winding being concentrated on polepieces, it is distributed in slots in the inner periphery of a laminated core. The stationary element of an induction motor, or in fact of most any alternating-current machine, is known as the stator.

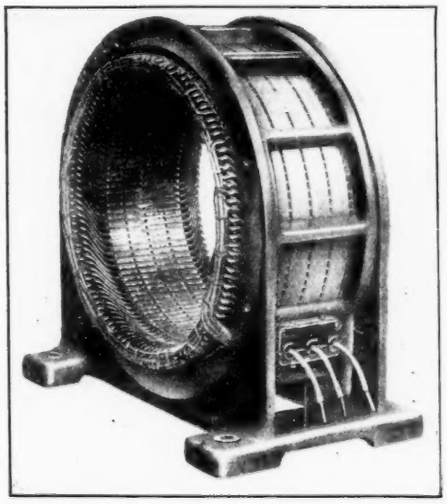
The rotating element of an alternating-current motor, which is generally called the rotor, is made in a wide variety of forms, and it is in this part that these motors differ most in their construction, as will be shown in subsequent articles. In the simple squirrel-cage type the rotor consists of a laminated core with copper bars in slots on the outer periphery, these bars being attached to end rings as in Fig. 2. The bars may be insulated in the slots or they may not, depending upon the make of the machine. This part of the machine has no physical connection to the power circuit, which is connected to the stator winding.

The induction motor might be considered as a combination of a transformer and a direct-current motor. The rotor winding has a voltage induced in it by the magnetic field set up by the current in the stator winding, just as the voltage is induced in the secondary of a transformer by the magnetic field set up by the current in the primary winding. For this reason the stator winding of an induction motor is called the primary and the rotor winding the secondary. The voltage induced in the rotor winding sets up a current that reacts upon the stator's magnetic field in much the same way as the current in the armature conductor of a direct-current motor reacts upon the magnetic field in the polepieces, to produce a turning effort, torque. There are a number of alternating-current motors that have an insulated winding and a commutator on the rotating member, as indicated in Fig. 4. On looking at this picture, one could not be blamed for taking it for the armature of a direct-current machine, but it is the rotor from a polyphase commutator-type alternating-current motor.

Rotating Magnetic Field

In the induction motor the current in the stator's distributed winding produces a magnetic field similar to the field coils on the polepieces of a direct-current machine. Furthermore, the magnetic field is caused to rotate in a polyphase machine, that is, a machine designed for two or more phases, just as though the field frame of a direct-current machine were mounted in bearing, the field coils excited and the frame rotated in space. In the polyphase machine this field is caused to rotate by the action between the magnetic fields set up by the two or more phases.

When an electric current flows through a conductor, it sets up a magnetic field that rotates about the conductor as indicated in Figs. 5 and 6. When the current



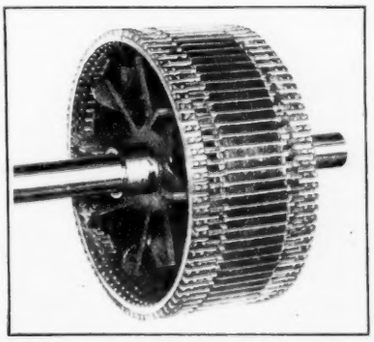
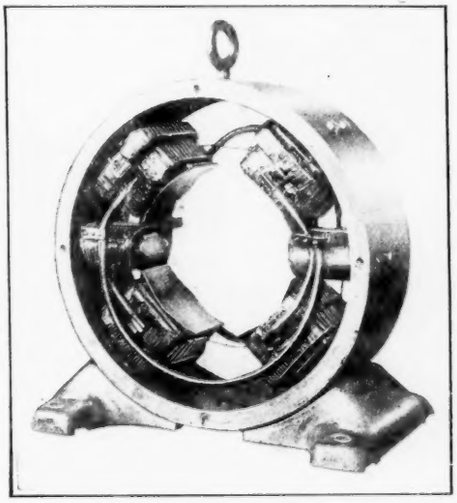


Fig. 1—(Left) Induction-motor's stator
Fig. 2—(Above) Squirrel-cage rotor for induction motor
Fig. 3—(Right) Field frame for direct-current machine



is flowing away from the reader, as indicated by the cross in Fig. 5, the magnetic field rotates in a clockwise direction. While the current is flowing toward the reader, as indicated by the dot in Fig. 6, the direction of the field is counterclockwise. It will be seen from Figs. 5 and 6 that the direction of the lines of force between the two conductors is the same—in this case, downward. If the positions of the two conductors were interchanged, that is, conductor *A* placed on the right, the direction of the magnetic field between the conductors would be upward. Where the lines of force enter the space above the conductors, Figs. 5 and 6, it gives the condition of a south pole, and where they leave below the conductors a north pole is created, just as would exist in a one-turn coil.

Magnetic Field About Electric Conductors

Where two conductors have current flowing in the same direction as in Fig. 7, the lines of force between the conductors are in opposite directions, as indicated. If these conductors are moved near together, the two fields combine and surround the two conductors as in Fig. 8. These are the simple principles that are involved in setting up the magnetic field in the primary winding of an induction motor. Assume that in a slotted iron core there are two groups of conductors,

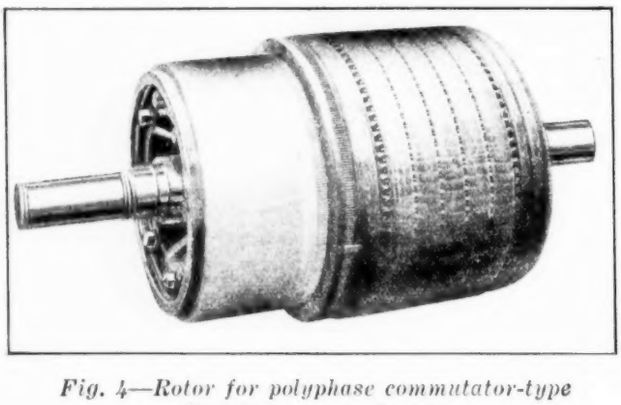
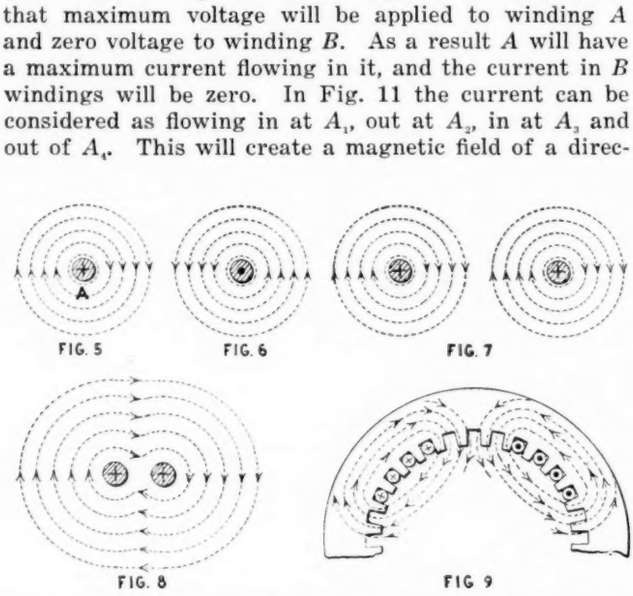


Fig. 4—Rotor for polyphase commutator-type alternating-current motor

as in Fig. 9, with the current flowing away from the reader in the left-hand group and toward the reader in the right-hand group. From the direction of the magnetic fields indicated in Figs. 5 and 6, it will be seen that the current in the two groups of conductors, Fig. 9, will produce a field having a direction as indicated. This shows how the magnetic field is set up in the stator of an induction motor.

To explain how the rotating magnetic field is produced, a two-phase motor will be assumed, as this will be simpler than the three-phase. In Fig. 10 are shown two curves representing the voltages in a two-phase circuit. It will be seen that when curve *A* is at a maximum, *B* is at zero, and when *B* is at maximum value, *A* is at zero. These voltages are produced by placing two windings in the generator in such a way that when one is generating maximum voltage, the other winding is in a position of no voltage.

In the two-phase induction motor there are two groups of windings as indicated by A_1, A_2, A_3, A_4, and B_1, B_2, B_3, B_4, Figs. 11 to 16. Assume that voltage is applied to the windings, Fig. 11, at the instant indicated at *a* in Fig. 10. From Fig. 10 it will be seen that maximum voltage will be applied to winding *A* and zero voltage to winding *B*. As a result *A* will have a maximum current flowing in it, and the current in *B* windings will be zero. In Fig. 11 the current can be considered as flowing in at A_1, out at A_2, in at A_3 and out of A_4. This will create a magnetic field of a direc-



Figs. 5 to 9—Magnetic fields set up by current flowing in electrical conductors

tion and polarity as indicated in the figure. At instant *b* on Fig. 10, voltage *A* has decreased and *B* has increased until the are both the same value and in the same direction. If these voltages are applied to the two-phase windings, it will produce a condition as indicated in Fig. 12. Current is flowing in the same direction in the *B* conductors as in the *A* groups and gives the effects shown. Now, instead of the center of the magnetic field being halfway between the *A* groups of conductors, it is between the *A* and *B* groups. This has resulted in a movement of the field in a clockwise direction.

At instant *c* on Fig. 10, the voltage in *B* phase has reached maximum value and in *A* phase it is zero. This would produce a condition in the motor windings

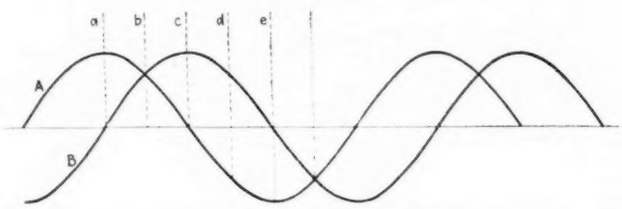
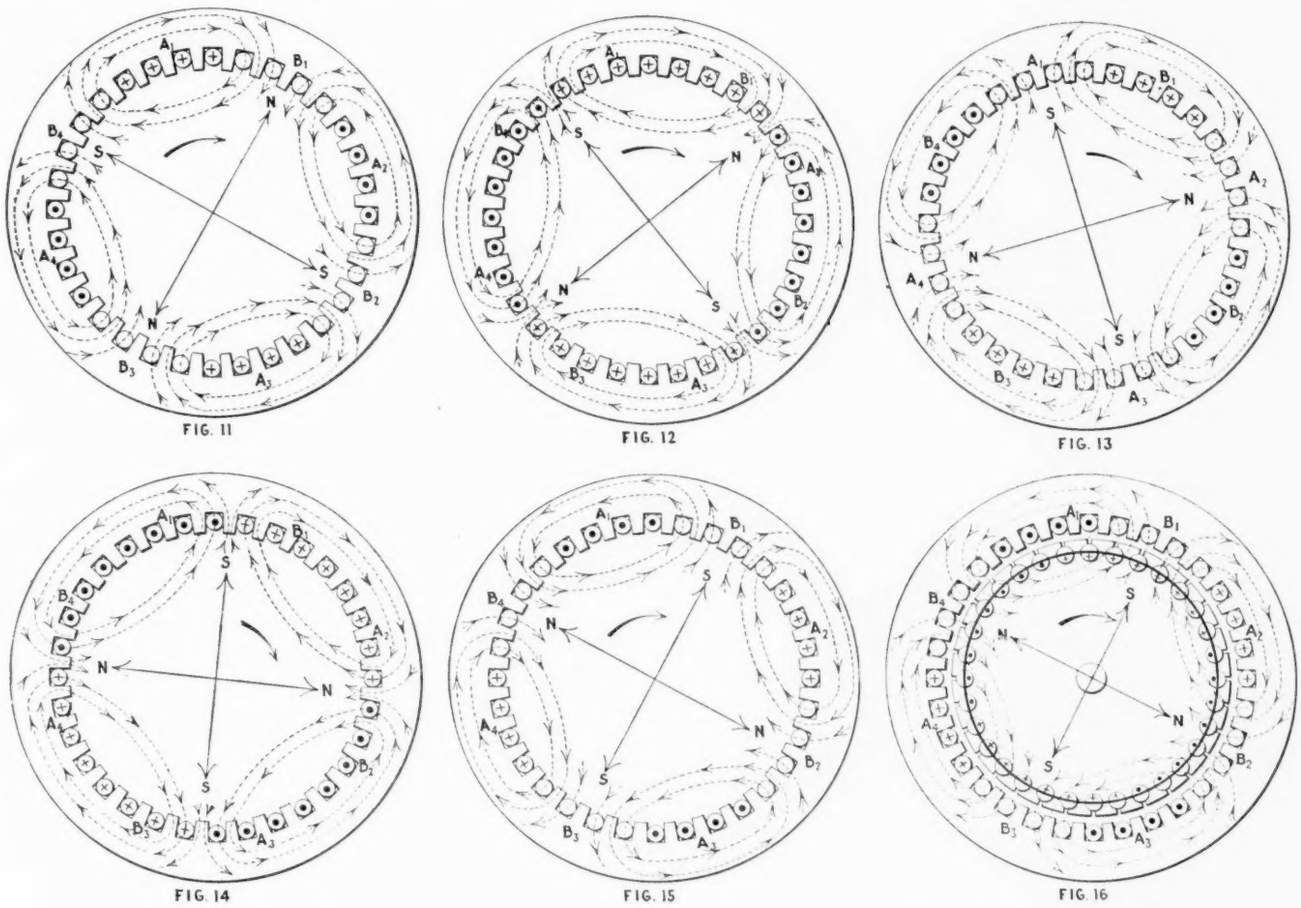


Fig. 10—Two-phase voltage or current curves

as in Fig. 13. The center of the magnetic field has shifted in a clockwise direction from between the *A* and *B* phases to the center of the *A* phase, as indicated by the arrows. Referring to Fig. 10 again, it will be seen that at instant *d* the voltage in *A* phase is equal to that in *B* but in an opposite direction. Applying this condition to Fig. 14, the current will enter the *A* winding at A_1 and leave at A_1 and gives the condition shown. This has caused the center of the magnetic field to shift again in a clockwise direction. At instant *e* on the curves, Fig. 10, the voltage in *A* phase is at a maximum and that in *B* at zero, just as it was at *a*, except that the voltage of *A* is reversed. Therefore, in the motor windings, Fig. 15, the conditions will be

the same as in Fig. 11, except that the current will be reversed in A phase. The magnetic field again has moved around in a clockwise direction, as shown.

In Fig. 10 the cycle of events has been followed through for one alternation. In doing this, the magnetic field in the motor, Figs. 11 to 15, has shifted one pole space in a clockwise direction. For example, in Fig. 11 the S poles are at B_2 and B_4, where in Fig. 15 they are opposite B_1 and B_3. In other words, for each alternation that the current passes through, the magnetic field in the stator of the motor shifts one pole space. In the four-pole machine, used in the figures, the magnetic field revolved 90 deg. or one-quarter revolution. With a six-pole machine this would have been one-sixth of a revolution and for an eight-pole machine, one-eighth of a revolution.



Figs. 11 to 16—Representing how a revolving magnetic field is produced by a polyphase current in an induction motor

Alternating-Current Motor's Speed

The frequency of an alternating-current circuit is expressed in cycles per second, one cycle equaling two alternations. Then in one cycle the magnetic field in the stator of the motor would revolve through the space of one pair of poles. Therefore the number of revolutions made by the magnetic field in one second will equal the frequency of the current, cycles per second, divided by the number of pairs of poles. A four-pole machine has two pairs of poles, and on a 60-cycle circuit the magnetic field will rotate at a speed of $60 \div 2 = 30$ revolutions per second, or $30 \times 60 = 1{,}800$ revolutions per minute.

If S is let equal the revolutions per minute made by the magnetic field, $\frac{P}{2}$ the number of pairs of poles in the motor, and f the frequency of the power circuit in cycles per second, then $S = \frac{120f}{P}$. For a 4-pole motor on a 60-cycle circuit the speed of the magnetic field is $S = \frac{120 \times 60}{4} = 1{,}800$ r.p.m., as was obtained in the foregoing. On a 25-cycle circuit and a 4-pole motor, $S = \frac{120 \times 25}{4} = 750$ r.p.m. From this it is seen that on a 60-cycle circuit the speed of the magnetic field in a 4-pole motor will be 1,800 r.p.m. and on a 25-cycle circuit 750 r.p.m. The speed of the magnetic field as found by this formula is known as the synchronous speed. The formula may be transposed to read $P = \frac{120f}{S}$ for finding the number of poles when the speed and frequency are known. It can also be transposed to read $f = \frac{PS}{120}$, for finding the frequency when the poles and speed are known. These formulas apply to alternating-current generators as well as to induction and synchronous motors.

In Fig. 16 is shown a squirrel-cage rotor in the stator. If the rotor is held stationary, the magnetic field of the stator will revolve by the conductors in the rotor

and generate a current in them. Since the rotation of the magnetic field is in a clockwise direction by the conductors, it will be the equivalent of having the field stationary and turning the rotor in a counterclockwise direction. Applying the rule for an electric generator to the rotor conductors, it will be found that current will be produced in the direction indicated by the crosses and dots. Applying the rule for the direction of rotation of a motor to the direction of current in the rotor's conductors and the direction of the stator's magnetic field, it will be found that the rotor will tend to turn in the same direction as the stator's magnetic field. Therefore, in an induction motor the rotor revolves in the same direction as that of the stator's magnetic field.

Slip of an Induction Motor

With the rotor stationary the magnetic field will move by the rotor's conductors at a rate determined by the frequency of the power circuit and the number of poles in the rotor. That is, with a 4-pole motor on a 60-cycle circuit the speed will be 1,800 r.p.m., which will generate a maximum current, having line frequency, in the rotor conductors. If the rotor is driven at the same speed as the magnetic field, the rotor's conductors will not cut the lines of force in the stator's field, consequently the voltage in these conductors will be zero, and no current will flow. This being the case, no torque will be developed; therefore, in order that current may be caused to flow in the rotor's conductors, it must turn at a slower speed than the magnetic field of the stator. In practice this difference in speed amounts to from 3 to 20 per cent, depending upon the design of the motor. The difference in speed between the magnetic field of the stator and the mechanical speed of the rotor is called the slip and is usually expressed as a percentage. If S is let represent the speed of the magnetic field (synchronous speed) S' the indicated speed of the rotor, the

$$Per\ cent\ slip = \frac{(S - S')\ 100}{S}$$

For example, an 8-pole motor connected to a 60-cycle circuit runs at 850 r.p.m. Find the per cent slip?

The synchronous speed $S = \frac{120f}{P} = \frac{120 \times 60}{8}$ = 900 r.p.m., and

$$Per\ cent\ slip = \frac{(S - S')\ 100}{S} = \frac{(900 - 850)\ 100}{900} = 5.6\ per\ cent.$$

On starting an induction motor the stator winding is connected to the line and a current flows through the winding and produces a rotating magnetic field that, as long as the rotor is at standstill, revolves by the conductors at a speed equal to the synchronous speed of the machine. This sets up a heavy current in the rotor's conductors of a frequency equal to the line frequency. As the rotor comes up to speed the current and frequency decrease in the rotor's conductors until a speed is reached where the current in the rotor is just sufficient to produce the necessary torque to carry the load. This speed, as has already been shown, must be less than synchronous speed, for if the rotor is made to revolve at the same speed as the magnetic field, it has no voltage generated in its conductors to set up a current to produce torque. If the load is increased on the motor, the rotor decreases in speed so that a voltage and current will be generated in the rotor's conductors to produce the necessary torque to carry the load. If the increase in load is too great, the motor will be stalled. The torque developed when the motor was stalled is known as the pull-out torque. The torque that an induction motor will develop before stalling will vary from about 150 to 250 per cent full load torque, depending upon the design of the machine.

The current in the stator's winding of an induction motor is limited by the ohmic resistance of and the counter-electromotive force generated in the winding just as in the primary of a transformer. Under normal operating conditions the current in the rotor conductors is in a direction to have a demagnetizing effect on the stator, so that as the load increases on the rotor, the increased current in the rotor reduces the flux due to the stator current. This in turn reduces the counter-electromotive force in the stator, and a greater current is taken from the line to balance the effects of the rotor's current.

Induction Generation Operation

If the rotor of an induction motor is driven above synchronous speed, the rotor's conductors will be cutting the lines of force from the stator in an opposite direction to that when running slower than the stator's magnetic field. If the current in the rotor is demagnetizing when the speed is below synchronous, then with the rotor running above synchronism its current will be magnetizing and increase the flux in the stator. This in turn will increase the counter-electromotive force in the stator's winding. When the rotor speed is increased one or two per cent above synchronism, the counter-electromotive force in the stator's winding becomes equal to the applied voltage and for any further increase in speed the stator's windings will deliver a current to the line instead of taking current. When an induction motor is operated in this way, it is known as an induction generator. Generators of this type have been built in sizes up to 7,500 kw. Such machines must always be connected in parallel with synchronous generators to supply the exciting current. Where induction motors are used on elevators, if the load in the car tends to overspeed the motor, it becomes an induction generator and supplies power back into the system, in the same way as a direct-current motor will, and acts as a brake to keep the car and its load under control.

Slip of a pump is the percentage of piston displacement that is not realized, owing to defective piston packing, leaky stuffing boxes or valves, the delayed closing of the valves or the amount of air carried into the pump body by the water. In a new pump that handles water reasonably free from air, the slip rarely exceeds 2 per cent of the piston displacement when the pump is operated at normal capacity, and in packed pumps, where there is no leakage past the plunger or piston, the percentage of slip is less. Pumps handling large quantities of water have shown slips of $\frac{1}{2}$ per cent, no slip, or negative slip; that is, the delivery of water has been in excess of the piston displacement from the tendency of the water to flow after the plunger has stopped. With large pumps it is difficult to determine the slip accurately, as there is no absolutely reliable method of measuring large flows of water, and the error of measurement is likely to be more than the slip in a pump in good condition.

The Diesel Engine in the Industries

By MAX ROTTER
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THE choice between purchased power, steam and the Diesel usually resolves into one of comparative power cost, and this cost is determined by three main conditions—the requirements, the locality, and the cost of the plant.

The power requirements comprise the amount and period of the load, as shown by a daily load curve, and the total annual horsepower-hours or kilowatt-hours. The fuel consumption, labor and other operating expenses can be closely calculated from these requirements and will vary according to locality for the same load conditions, or according to load conditions in the same locality. The results may be modified by special requirements, such as hot water or steam for heating or industrial processes, to which reference will be made later on. The Diesel engine possesses the unique characteristic that its efficiency is affected but little by the size of the unit. On one hand a multiplication of units, to maintain a high load factor, is therefore less objectionable than in the case of a steam plant; an advantage that is enhanced by the readiness of the Diesel to be put on load at any moment, without advance preparations. On the other hand, the Diesel maintains almost its full efficiency over a considerable range of load; at half-load its unit fuel consumption increases only about 15 per cent over that at full load.

IN THIS article, based on a paper before the recent Midwest Power Conference, the author evaluates the Diesel engine in meeting various factors that enter into the selection of a prime mover for industrial-plant service. Suggestions are also made as to suitability of oil, quantity and quality of cooling water, maintenance and fixed charges.

Generally, the fuel costs will have to be compared on the basis of coal for the steam plant and fuel oil for the Diesel, and, in making this comparison, due allowance must be made for stand-by conditions—that is, the preparedness to take care of increasing loads and to start up after nightly or other shutdown—as also the inevitable heat losses resulting from condensation and leakage of steam between the boilers and the steam-using machine.

Concerning the permanence of the supply of fuel oil there need not be any misgivings. There has been about the same volume of calamity-prophesying relating to the exhaustion of coal as of petroleum. It is reasonable to assume that the supply of both classes of fuel will last as long as they are needful. The fear that the processes of "cracking" petroleum to increase the production of gasoline might seriously restrict the supply of fuel oil is also not being fulfilled. So far, these processes have left available an ample quantity of oil which it would not pay to crack, or which remains after cracking and which is suitable for Diesel fuel.

In connection with this subject it may be pertinent to refer to the properties that affect the suitability of a fuel oil for use in a Diesel engine. In the old days the primitive systems of lubrication and the over-cautiousness that is natural in connection with unfamiliar apparatus led the builders of Diesel engines to set up quite elaborate specifications for the fuel. Today the limitations have been reduced to a few simple ones; although even the modern Diesel engine cannot be operated continuously and satisfactorily with every liquid fuel that can be injected into its cylinders. The fuel must be clean, to avoid difficulties with the fuel pump and other working parts with which it comes in contact. It must be substantially free from water, which may cause difficulty with the regulation and which, in any event, reduces the thermal value of the fuel. The worst of the dirt and water may be settled out; most of the remainder can be eliminated by coarse straining, followed by centrifuging, and, lastly, by filtering. The coarse straining should be done as the tank car is being emptied into the bulk storage; the centrifuging, between the bulk fuel storage and the service or station tank; the final filtering, between the service tank and the engine fuel pump. The viscosity of the fuel oil must be sufficiently low for it to flow freely, to which end heavy fuels may have to be heated, which may be conveniently done by means of the hot water from the engine jackets; but the oil should not have to be heated to a temperature at which it gives off vapors, as they may affect the regulation, by forming gas pockets or, if vented off, will constitute a loss of fuel value. The question of sulphur may almost be ignored; it may be taken for granted that a fuel oil originating in this country does not contain enough sulphur to injure any part of the engine. The asphaltum content, as ordinarily determined, is no guide; while the various methods of determining "residues" have a limited value as indications.

As yet, means do not appear to have been established to differentiate between residues that will be consumed or partly consumed, or not consumed at all at the temperature and within the time-limit obtaining in a Diesel cylinder. Of importance equal to, if not greater than, that of the water in the fuel is the ash, composed of truly non-combustible substances, which do not, as do the merely less readily combustible constituents, form a gummy accumulation; but the ash is left as a hard grit, which acts as an abrasive between the piston and cylinder surfaces. The particular type of Diesel engine has nothing to do with the effect of the ash, and a fuel should not, under any circumstances or at any price, be used if, in the condition in which it is delivered to the engine—that is, after the fuel filtering—the ash content exceeds 0.05 per cent by weight; while a limit of 0.02 per cent is much to be preferred.

The specific gravity, usually measured in degrees Baumé at 60 deg. F., is little more than a general indication of the properties that may be expected, and this determination has been entirely omitted from the Government Standard Specifications for fuel oils. How-

ever, as it has become the accepted commercial practice to grade fuel oils according to specific gravity, they must usually be purchased on this basis; and it will be found that fuel oils ranging between 24 and 34 deg. Baumé at 60 deg. F. are usually to be preferred—the heavier grades in warm climates, the lighter grades in cooler climates. If conditions of price warrant it, some fuels heavier than 24 deg. may be used; but fuels lighter than 34 deg. should be avoided, as they are generally more expensive and have a tendency to wash off the lubricants. The flash point is of importance only as it affects safety in storage, and will usually be objectionable only if under 125 deg. F.

Cooling Water a Factor

Although ordinarily a minor item of expense, the water for cooling the Diesel engine is a matter of importance. In a steam plant the character of the water must be considered, as affecting the boilers, heaters and condensers; in a Diesel plant, as affecting the jacket spaces; and in both plants, as an item of cost, whether purchased or pumped. Water that is suitable for use in a boiler is, *ipso facto*, suitable for use in a Diesel engine; but the reverse is not necessarily true. To some extent hardness of the water may, in the case of the Diesel, be offset by circulating enough to keep its temperature down to a point at which it does not precipitate its impurities. In witness of this may be cited the regular use of sea water in the jackets of marine Diesel engines. Whether for steam or for the Diesel, the water must be free from suspended solids—mud, sand, leaves, etc.—and these may be removed by settling, skimming and straining. If the water, in its raw state, is not suitable for use, it should be purified; or pure water used over and over, with purified makeup. In a Diesel plant the water may be cooled for re-use in a simple heat-exchanger, using raw water as the cooling medium; or a cooling tower or spray pond may be used; any one of which will be smaller than similar provisions for condensing water, because the cooling for the Diesel is from and to higher temperatures.

The quantity of cooling water circulated through the jackets of a Diesel engine is governed by the load on the engine, the initial temperature of the water and its permissible discharge temperature. It is preferable that the initial temperature be not under 60 deg. F. The discharge temperature may range from 110 deg. F. for brackish water to 125 deg. F. for water of 12 deg. relative hardness or 150 deg. F. for soft water. The heat to be carried off in the water from a Diesel engine may be assumed to be 3,000 B.t.u. per b.hp.-hr. The quantity of water required by the Diesel plant is, thus, roughly between one-sixth and one-tenth of that required by a condensing steam plant under the same load conditions. On the other hand, although the boilers require purer water than is necessary for the Diesel, the condensers can operate satisfactorily with water that should not be used, in its raw state, in a Diesel engine.

Regarding the cost of the superintendence and labor for operating a Diesel plant, it was, in the early days, assumed that, to obtain equivalent results, a Diesel plant required more highly trained personnel than did a steam plant. Time has proved that there is no difficulty in quickly training an intelligent steam-plant operative into an equally competent Diesel engineer or attendant.

Another important operating expense is the cost of lubrication. This varies widely, in line with personalities of the crews. For a Diesel engine plant the consumption of lubricating oil may safely be taken at the rate of one gallon per 2,400 b.hp.-hr. with small engine units, down to one gallon per 3,000 b.hp.-hr. with large engine units. Roughly, the cost of lubrication in a Diesel plant has been found to be about one-tenth of the fuel cost in a small, to one-twelfth in a large plant.

Maintenance and Life of Diesel

The only remaining important item of operating expense is the maintenance of the machinery. For Diesel engines, records carefully kept over an extended period indicate that this expense may be figured conservatively to be $1 per 2,500 b.hp.-hr. for small engines, down to $1 per 5,000 b.hp.-hr. for large engines. This is substantially the same as for equivalent steam plants, including the boilers, being somewhat lower with steam turbines and somewhat higher with steam engines.

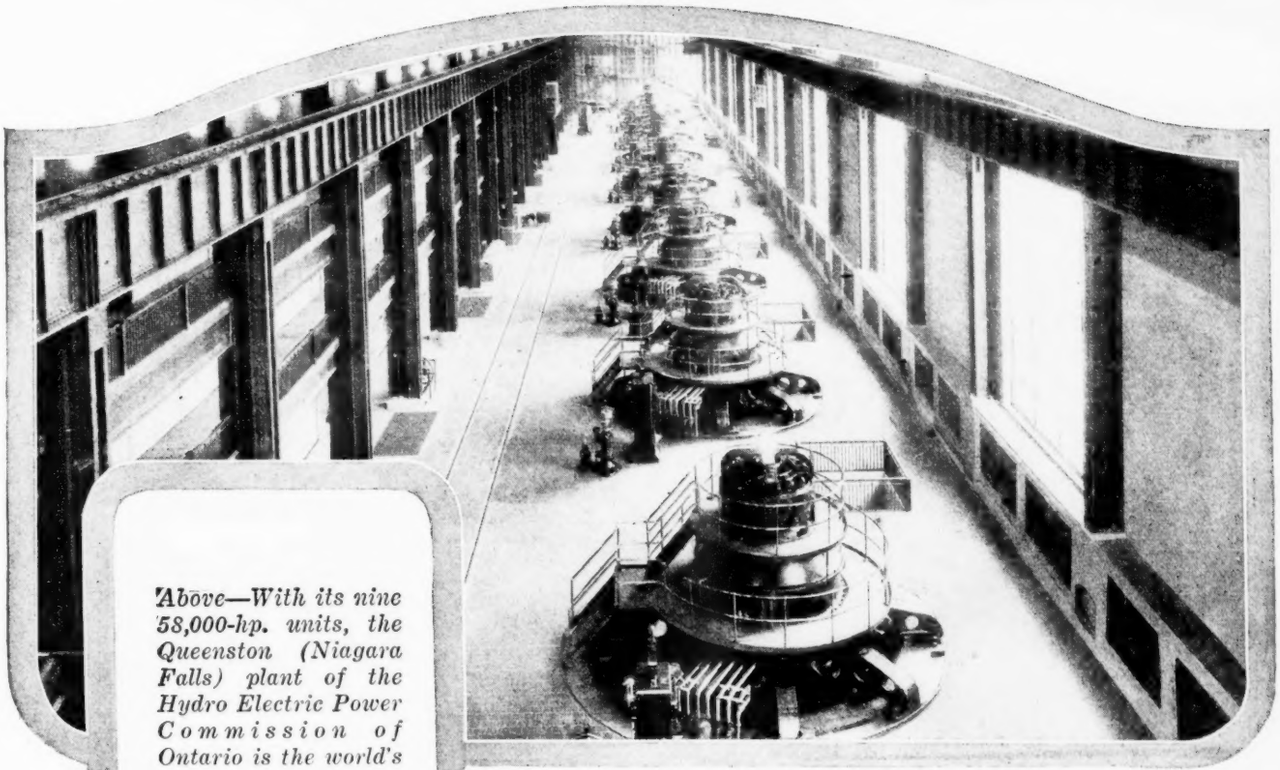
Based on actual experience, it is safe to assume the useful life of a Diesel engine to be 25 years. A well-known firm of engineering appraisers has even suggested 30 years, and a number of Diesel engines that were installed 21 years ago are still in regular operation, with undiminished efficiencies; whereas practically none have been discarded.

In calculating fixed charges care should be exercised to avoid the all too common and exceedingly misleading error of summing up the fundamental percentage rates and applying the sum to the total investment over the total period of life. Regardless of the disposition of reserves for depreciation, whether in the periodical retirement of bonds or in the creation of a sinking fund or in extensions or improvements to the plant, it is clear that the value of the original tangible assets, represented by the investment made in them, is each year reduced by the amount of their annual depreciation. Therefore, the charges for interest, taxes and insurance must be reduced accordingly, by applying an average percentage rate based upon the entire assumed life and the applicable method of disposing of the reserves. It is surely clear that, if $100,000 is invested in a plant, the assumed life of which is 25 years, and the interest rate 7 per cent per annum, it is improper to write off 4 per cent depreciation per annum, and to continue to load the annual fixed charges with 7 per cent of the original $100,000.

Recovery of Rejected Heat

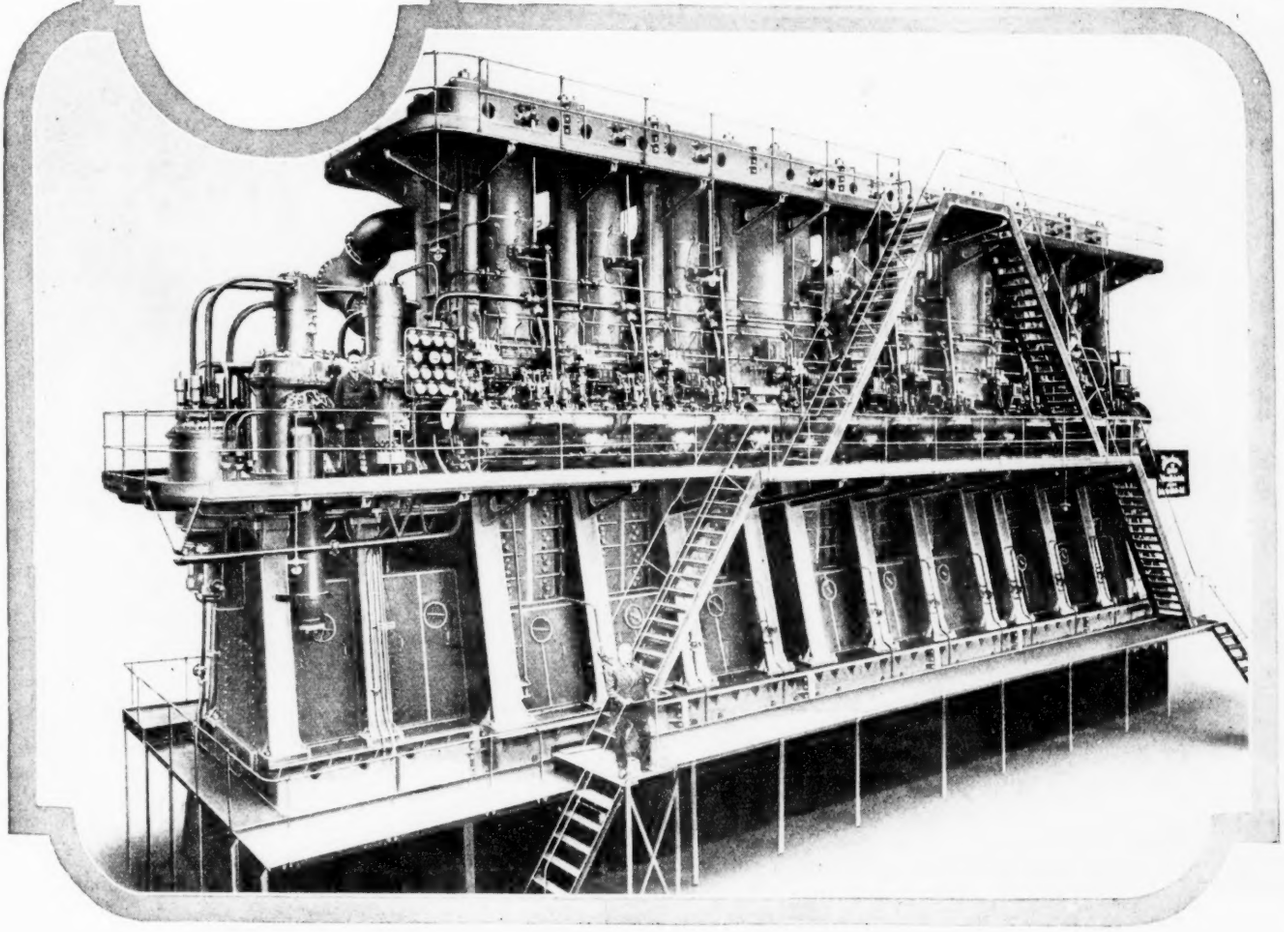
Something is already being done in the utilization of the heat rejected by Diesel engines; but much more can be accomplished in this direction. The temperature of the exhaust gases leaving a Diesel engine is 400 to 700 deg. F. and even higher, according to the type of the Diesel and the load it is carrying. As previously stated, the jacket water leaves the engine at somewhere between 110 and 150 deg. F. Of the total heat value of the fuel consumed, the exhaust gases carry off about one-quarter, and the jacket water about one-third; that is, the heat rejected by the engine through these two media amounts to 55 or 60 per cent of the total heat value of the consumed fuel, a substantial part of which rejected heat can be reclaimed.

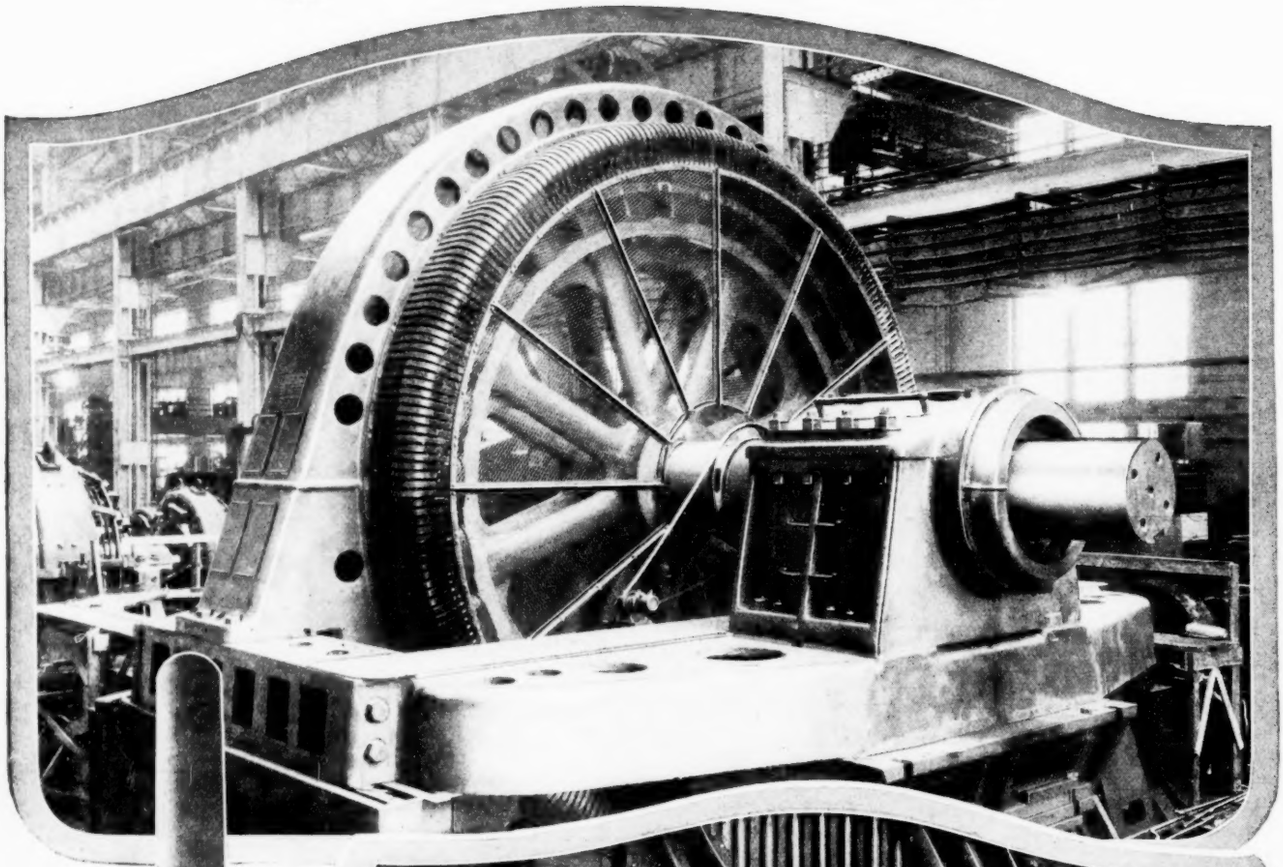
One of the largest industrial Diesel-engine power plants at present operating in the United States is generating power for the reduction of copper ores. This plant has a total installed capacity of 6,500 b.hp., in Diesel engines up to 2,000 b.hp. unit capacity.

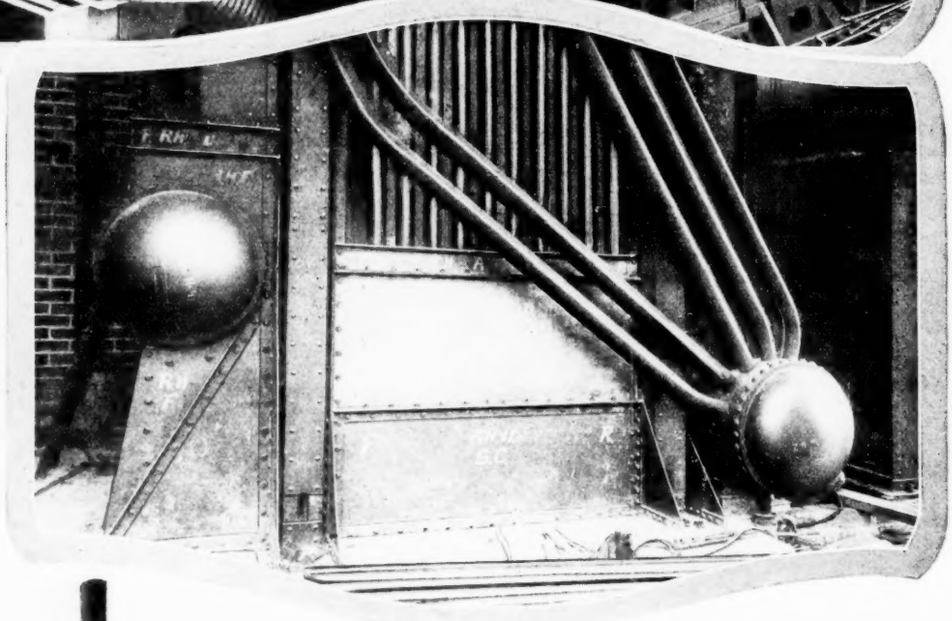


Above—With its nine 58,000-hp. units, the Queenston (Niagara Falls) plant of the Hydro Electric Power Commission of Ontario is the world's largest power station. It has carried a peak load of 552,000 hp.

Below—Largest oil engine yet built. This 15,000-b.hp., nine-cylinder, two-cycle Diesel engine will supply electricity for Hamburg, Germany. It is 77 ft. long, 14 ft. wide and 39 ft. high







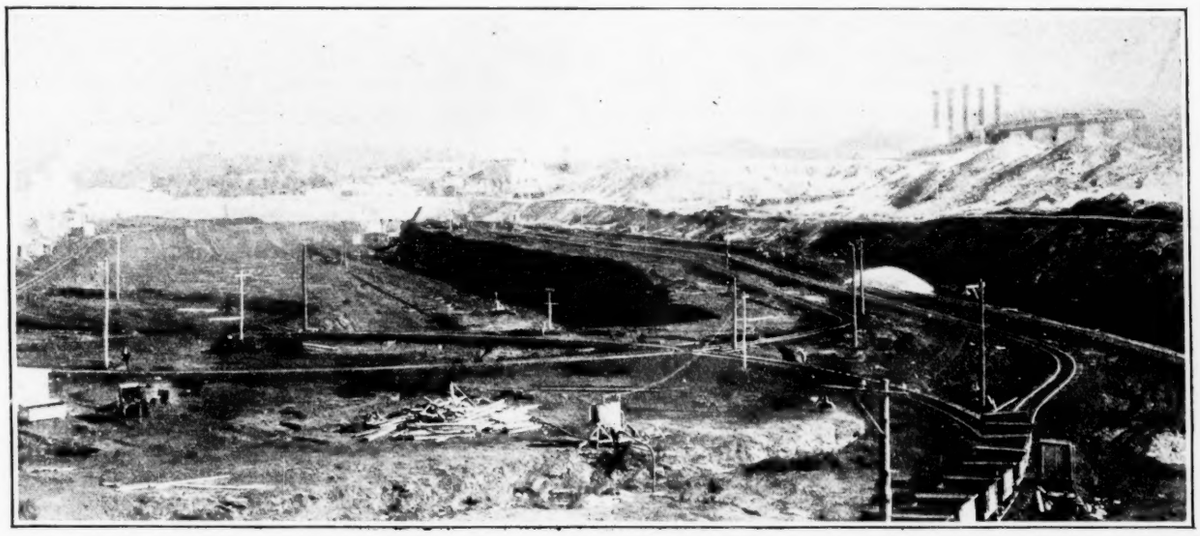
Top—This 9,000-hp. G. E. synchronous motor has the highest continuous horsepower rating of any industrial motor in the world

Center—Ratings as high as 1,200 per cent have been obtained on this Combustion steam generator recently installed at the plant of Taylor Bros., Manchester, England

Bottom—The 400-ft. reinforced concrete stack at Tadanac, B. C., is the tallest of its kind on the American Continent

The Morwell-Yallourn Power Project*

New 62,500-Kw. Steam Plant, Located at the Australian Coal Fields, Burns Brown Coal Running Up to Sixty per Cent Moisture—Chain Grate Stokers, Return Arches and Waste Heat Driers Are Employed



Stripping the coal adjacent to power house

EARLY in 1918, when the State of Victoria was threatened with a serious shortage of electric power, the Committee on Brown Coal Utilization, appointed by the Victorian government, presented a report dealing with the state's vast deposits of brown coal. It recommended that the future electrical requirements of the state should be drawn from these resources and that the then existing power plants be supplemented by the erection of a new power house designed to carry an ultimate load of 100,000 kw. and an initial load of 50,000 kw.

Within a year the State Electricity Commission was established by law. The duties imposed on the Commission under the act may be broadly divided into two main sections:

1. The control of the generation, supply and use of electrical energy, throughout Victoria.

2. The investigation of possible sources of power and the exploitation and development of any such resources of power supply, selected by the Commission.

In November, 1919, the newly formed Commission presented its first report, in which it recommended that steps be taken to inaugurate a state scheme for the supply of electrical energy, beginning at the Morwell brown coal fields, where a power house should be established, with the necessary substations and transmission lines connecting all state-owned stations. This plant it was proposed to tie in with the existing plant at Newport, near the City of Melbourne, and an addition to the latter was planned. The project involved building living accommodations near the brown coal fields, at a place known as Yallourn, which is a native word meaning "brown fire." It was further recommended that briquetting machinery be authorized and that research work with brown coal be undertaken on a sufficiently large scale to determine the commercial possibilities of its utilization in connection with byproduct recovery and as pulverized fuel.

After deliberation it was decided that the Morwell brown coal field in Gippsland, 112 miles from Melbourne, should be opened up, and that in addition to an electric power station, a briquet factory should be established.

Coal Sufficient for 100 Years

Work began with extensive borings at Morwell covering one square mile to the south of the site chosen for the power station, proving the existence, it said, of 150,000,000 tons of coal, estimated to be sufficient to supply a power station of 200,000 hp. for 100 years.

Brown coal, as found in Australia, is mined in an open cut, using power shovels for loading the material into cars. The overlying earth varies in thickness from 20 to 40 ft., and this must be stripped off and piled alongside before real mining operations begin. The thickness of this overburden averages 28 ft. It consists of sand, sandy clay and gravel. Between two and three thousand tons of coal per day are taken out of the pit by means of an electric shovel which handles 6 tons at each operation. A smaller steam shovel is used to supplement the work of this large electric machine.

The shovels deliver coal to cars which dump it into a crusher. It then passes by conveyor belt to a loading station where it is automatically loaded into small cars

*From information supplied by E. T. Pawly, Assistant Trade Commissioner, U. S. Department of Commerce, at Melbourne, Australia.

with drop bottoms on an endless cableway, over which it is taken to the screening plant. The screening plant is located over railway sidings from which coal may be readily conveyed to the power plant, to the briquetting plant, or to the large concrete storage bunkers.

Vibrating screens separate the smaller size lumps from the larger, lumps up to 2½ in. passing through the screen and larger material passing to the crushers. The high moisture content of this coal, running up to 60 per cent, makes screening difficult. The storage bins of 2,500 tons capacity, at the side of the screening plant, are arranged with separate compartments for various sizes of screened coal.

The coal for the power plant is carried over an automatic hauling and dumping system to the receiving hoppers or to storage from which it is reclaimed by a 3½-ton grab bucket running on an elevated trestle.

Coal handling at the power plant

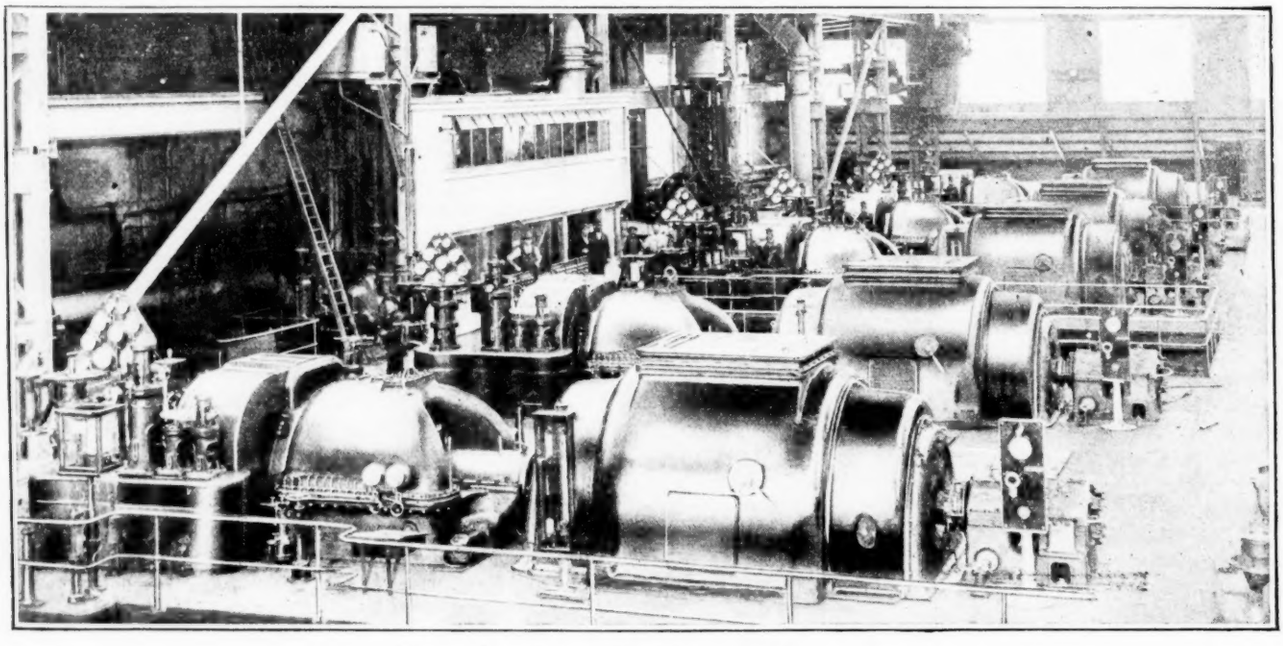
Manufacture of Briquets

Similar equipment delivers coal into the hoppers at the briquetting plant. Coal received at the briquetting plant is subjected to a preliminary wet preparation, in which it is reduced to a maximum size of about ¾ in., and in which the woody portions are separated and diverted to the boiler house for steam-raising purposes. The resulting fine coal is passed through tubular driers, where it is steam-heated by exhaust steam from the presses and from a 1,500-kw. turbo-generator. It is then conveyed to the cooling plant and during a slow descent through twelve parallel sets of staggered steel plate louvers, it is thoroughly mixed, cooled by exposure to the air, and conveyed to the press-house. Here it is distributed among five presses, which extrude briquets into steel launders. These are pushed along automatically to the storage shed, where they are dropped directly into railway cars or stored under cover in the storage shed. The presses form the briquets under a pressure of some 200 tons.

The power station now has a capacity of 62,500 kw. in five units of 12,500 kw. each. In addition there is a 600-kw. house turbo-alternator. Steam is supplied at 260 lb. and 700 deg. by twelve 14,425-sq.ft. boilers. These are of the three-element steeply inclined water-tube type with three horizontal steam drums and three mud drums. Each boiler is served by three chain-grate stokers, motor driven and operating at eight speeds from 0.25 to 1.5 ft. per min. Owing to the high moisture content of the coal return ignition arches are provided over each stoker for about two-thirds the length of the furnace. By this means the gases are made to flow in the opposite direction to the travel of the grates. In addition, half of the boilers are fitted with waste-heat driers by means of which the flue gases pass around the coal chutes on their way to the stacks.

At maximum rating of the boilers the stokers are reported to have burned 98 lb. of coal per square foot per hour.

The main transmission line from Yallourn to Melbourne is 112 miles long and operates at 132,000 volts, much of the transmission equipment being imported from the United States.



Power is generated by five 12,500-kw. units

Motor-Driven Pump Compresses Steam for Ovens

By GUY B. RANDALL
Chief Engineer, Power Station, National Cash Register Company

AMONG engineers who have carefully studied drying and baking problems, whether for paper, lumber, japanning, enameling, vulcanizing or some other purpose, the knowledge exists that an entirely satisfactory oven or similar heating device for temperatures up to 450 or 500 deg. F. would generally have to combine the safety, economy and uniformity of temperature of a properly designed steam-heated system with the flexibility of the electric system. While a properly designed steam oven meets every requirement within the temperature range corresponding to the steam pressure available, the fact that temperatures are often required that exceed the usual steam pressures in a given factory has forced the industries to resort to the use of electric ovens, or to gas- or oil-heated ovens.

DISCUSSING higher steam pressures at the annual meeting of the A.S.M.E. in December, Mr. Randall made mention of the remarkable economies effected by the use of process ovens supplied with "compressed" steam, a slightly modified motor-driven air compressor being used to build up the steam pressure from that available in the distributing mains to that corresponding to the desired temperature of the oven. This article is the result of a request that he give further details. While it has long been realized that the steam-engine cycle could be reversed, this revelation of the practical possibilities of such an arrangement will doubtless interest many *Power* readers.

The simplest way to get uniform temperature is to surround the oven completely with the temperature desired and preheat entering air to oven temperature. This immediately suggests an oven with the walls completely lined with steam pipes, or a steam-jacketed oven with two staybolted steel walls with steam between and some air-preheating coils to take care of air changes. With such construction there is nothing for the inside steam surface to do except help to bring up the temperature quickly when a new charge is put in. The remainder of the time this surface acts catalytically; that is, it does nothing positive, but by its presence insures results. The *outside* surface supplies the radiation loss and by suitable construction does most of the heating of the ventilating air; that is, the ventilating air is made to travel over the outside of the heating surface. The final heating is done by a tempering coil. This is an ideal arrangement which can actually be obtained in practice without undue expense when all elements of the production cost are considered.

The writer will term this the "surface" type of oven because uniform temperature is obtained by relatively large heating surfaces which can be made to serve a double purpose by using them to form the framework of the oven. Heat insulation may be simply fastened to it.

From whatever angle considered, the case in favor of steam as a heating medium is very strong where the pressure is sufficient. But, obviously, a factory with a steam line at atmospheric pressure or 5 lb. gage cannot heat an oven requiring, say, 250 deg. F. or more. Likewise, a steam pressure of 100 lb. gage would not suffice for an oven requiring 350 deg. And if 10 per cent of the steam in a factory building is needed at 100 lb. and the remaining 90 per cent at 5 lb., either a duplication of steam lines is necessary or a 100-lb. steam line must be used. This in turn usually precludes the possibility of using bleeder or exhaust steam.

If an electric oven is used where the higher temperature is required, it means a great increase in operating cost whether power is purchased or whether it is generated locally. In the latter case it may result in throwing steam away (to the condenser or to the atmosphere) in order to generate the electricity. Also, in order to be safe, plant designers often provide industrial plants with steam-supply lines operating at much higher pressures than are actually required because of the fear that in some case a higher temperature than they expect *might* be required.

In order to remove this serious limitation in the use of steam, the writer suggests a system which, for want of a better term, he calls a steam-electric oven system. It has the simplicity, economy, precision, safety and cleanliness of a properly designed steam system without its limitation. The principal element of novelty is the reversal of the common engine or turbine cycle, which is so well known as to require little explanation.

For example, if a plant wanted to heat an oven, a roll or something similar, to a temperature of 250 deg. and had steam (line, bleeder or exhaust) at 50 lb. gage, it would simply connect to the 50-lb. steam line. But if the oven requires 350 deg. temperature, the practice is to resort to electric, oil or gas heating if, as is generally the case, there is some reason why it is impossible to raise the steam-line pressure.

The alternative plan is to take the steam at the factory line pressure, in this case 50 lb. gage, and compress it in a motor-driven (or otherwise mechanically driven) compressor to a pressure that will give the desired temperature. This is simply reversing the action that takes place in the usual engine-driven electric generator. Instead of expanding steam and getting electricity, the steam is compressed, just as air is compressed in the usual motor-driven air compressor, and at little expense for electricity the latent heat of the steam is made available at the desired temperature and pressure.

An actual study of an actual plant will serve to illustrate the economy and flexibility of the system.

A certain 6x7½x27-ft. oven (which may, if desired, be considered as three ovens each 9 ft. long) has a 250-kw. maximum demand and is supposed to operate at 350 deg. F. However, after extensive work in relocating resistors, the improved performance now is 350 deg. plus or minus 50 deg. It averages 160 kw. for twelve hours a day. (This results from 250 kw. for bringing up to temperature and 105 kw. "off again—on again" average thereafter). The average cost of this electricity is 1¼c. per kilowatt-hour at the power station, including all fixed charges. So the average cost of operating the oven is $2 per hour (160 kw.-hr. at 1¼c.), or about $6,600 per year of 3,300 hours (38 per cent of the time).

In the building and the department where the electric oven is located is a 50-lb.-gage saturated-steam main. It will require only a 7½x6-in. single-cylinder steam compressor driven by a 35-hp. 40-deg. motor to raise the steam pressure to approximately 300 lb. gage for bringing the oven up to temperature with the same speed as the electric oven and then dropping back to 120 lb. gage for the baking operation.

This compressed and superheated steam, when supplied to an oven of the surface type with tempering coils for air changes, will undoubtedly produce better results with an average electric-power requirement of 23 kw. and an average steam consumption of 508 lb. per hour. This is the weighed average and includes the extra electricity and steam for bringing the charge to oven temperature both on the regular cycle and for initial heating in the morning.

With electricity again at 1¼c. per kw.-hr. and steam at 40c. per thousand pounds, including fixed charges, the total cost is 49c. per hour, or $1,620 per year of 3,300 hours. In this case 12 per cent of the total heating is done by electricity and 88 per cent by steam. A 20 per cent loss of electricity has been allowed for radiation, friction, etc. By making the oven larger so more time could be taken to bring the oven contents up to temperature, the electricity percentage could be materially reduced—and this would produce still further savings, as the initial cost is not a very important factor compared with the operating cost.

In many cases it will doubtless be found that the steam pump is required only for bringing the charge up to temperature and that the steam at supply pressure is sufficient to hold it thereafter if the oven is properly designed.

The temperature control system may be of the type in common use with air compressors by governing through the pressure-temperature relation of a wet vapor, or an electric system may be used. Such a design insures a fast oven with closely uniform temperature. Emphasis is placed on truly uniform temperature because people are gradually learning that uniform temperature pays real dividends in improved quality and increased output. With uniform temperature part of the product is not over-baked or over-dried, while waiting for another part to be under-baked or under-dried.

For a comparatively simple explanation of the thermodynamics of the heat pump the reader may be referred to the article by Fritz Krauss in *Power*, page 298, Feb. 22, 1921. In the Krauss article comparatively small compression ratios are dealt with, but the principle and fact apply to greater ranges. However, as opposed to one of Mr. Krauss' statements it should be noted that highly efficient and economically sound reciprocating steam engines take steam at 350 lb. gage and 650 deg. and expand it to atmospheric pressure with an efficiency ratio as high as 80 per cent referred to the Rankine cycle.

The reverse of this operation, namely, the compression from atmospheric pressure to 350 lb. gage, is still more efficiently effected and at a modest expense in electricity. As a matter of fact, if the oven ventilating air is carried over the electric motor and steam compressor so as to absorb the losses of these machines, the efficiency of the steam system becomes identical with that of the electric system.

Once industry realizes, first, that highly developed and low-priced small air compressors are available with slight modification for heat pumps and, second, that the safe steam pressure to which 1½-in. commercial pipe or tubing properly welded or expanded into headers can be safely worked is upward of 400 lb. per sq.in., there seems little room for doubt that it will eventually draft them into its service. And the writer's single idea in this comparatively non-technical discussion has been to stimulate interest in possibilities and lend a truer appreciation to the anomalous fact that, in general, heating problems—like the steam boilers of old—are regarded as so simple that few people really understand them.

New High-Power Testing Laboratory

At the expense of several hundred thousand dollars a new high-power testing laboratory was put into operation on Dec. 1, 1925, by the Westinghouse Electric & Manufacturing Co. at East Pittsburgh, to be used primarily for testing the interrupting capacity of oil circuit breakers, contactors and fuses and the thermal capacity and mechanical strength of current-carrying parts in power stations, such as reactors, busbar supports, bus structures and current transformers. Due to the large amount of power thus made available, it will be possible to make extensive tests on oil circuit breakers which previously could be made only on power systems.

Forty thousand kva. in 13,200-volt, three-phase generators make possible the delivery to oil circuit breakers being given short-circuit tests, a maximum current equivalent of 700,000 kva., three phase. When a complete single pole of a circuit breaker is tested on single phase, an initial current can be impressed on the circuit breaker equivalent to more than 1,000,000 kva. on a three-phase system.

A great range of reactance values can be obtained due to the fact that a group of reactors is provided, together with suitable disconnecting switches. By means of these various connections on the generator and reactor groups, any current from approximately 500 amp. at 13,200 volts suitable for fuse testing up to a maximum of approximately 50,000 amp. at 3,800 volts for busbar testing can be obtained in fairly uniform steps.

In addition to the service described in the foregoing, this testing set will be available for completely testing large alternating-current generators, synchronous condensers and frequency converters. Used in conjunction with equipment already available on the company's test floor, it will be possible to test machines up to 50,000-kva. capacity at three-phase, 60 cycles.

The World Power Conference

IN 1924 Great Britain was inviting the world to Wembley to witness the integration of the British Empire.

Among the gatherings incidental to the colonial exposition was the World Power Conference, convoked largely upon the initiative of the British Electrical and Allied Manufacturers' Association.

This conference was attended by delegates from forty-four countries, and discussed nearly five hundred papers upon various phases of power. It resulted in bringing together the leading thinkers and workers in the power field, and while nothing new has grown out of its deliberations, it did succeed in focusing public attention upon power and its social-economical as well as its industrial importance, as nothing else has done.

The success of this occasion was such that a demand for its repetition was inevitable, and it has required considerable repression not to have another already on record or on the tapis. But although a call for another universal world power conference has been held in abeyance, there has been issued by the Swiss National Committee, with the approval of the International Executive Council of the World Power Conference, an invitation for a sectional meeting to be held in connection with the International Exhibition for Inland Navigation and Utilization of Hydraulic Power at Bale, Switzerland, August 31 to September 12 of this year.

Meanwhile the Executive Council of the World Power Conference, consisting of the chairmen of the various national committees represented at the original World Power Conference, continues to function. It held a meeting in London last year and seems disposed to constitute itself another permanent international organization with a secretariat, official journal, etc. How far the several national committees, loosely called together with no thought of anything more lasting than participation in the Wembley conference, will respond to the support of such a program remains to be seen.

A Record Performance with Obsolete Equipment

UNINTENTIONAL humor has been injected into the February issue of one of *Power's* contemporaries by the reproduction of a graphic pictorial chart illustrating what becomes of the energy contained in a ton of coal burned for power generation. It is a nicely drawn picture of a boiler, turbine, generator and motor hooked together, with labels indicating the various losses from coal pile to motor pulley. The humor arises from the incongruity existing between the types of apparatus pictured and the corresponding performance data.

The cycle starts with a small locomotive-type boiler, pleasingly sketched with a sheet-metal stack that appears to be about ten feet high. This evaporates nine pounds of water per pound of coal, and has an efficiency of sixty per cent, which, perhaps, might be obtained, seeing that the safety valve has been omitted, thus eliminating all wastage of steam at this point. What appears to be a two-inch pipe with several screwed fittings conveys the steam from the boiler to a turbine which, from its general shape and construction, is apparently a one- or two-stage machine of early vintage. This little turbine, however, is not to be sneezed at, for it is credited with producing one horsepower per pound of coal burned, or per nine pounds of steam. No condenser is shown, but its presence may be assumed to ease the situation somewhat. Good as is this turbine, it is a piker compared with the generator to which it is connected. Although the generator shown is of a type now long obsolete, it is credited with producing 0.746 kilowatt per pound of coal burned. Since the driving turbine generates one horsepower per pound of coal, and since one horsepower equals 0.746 kilowatt, it must be concluded that the generator has an efficiency of 100 per cent. The quaint little motor drops back toward normal by generating nine-tenths of a horsepower per kilowatt.

While allowances must be made for the fact that the article referred to deals primarily with power transmission by belting and only incidentally with power generation, this picture is likely to cause some merriment among the operating staffs of modern power plants.

Improving Efficiency of Hydro-Electric Plants

A LARGE PART of the cost for producing a kilowatt-hour from water power is for the money that must be invested in labor and materials for the construction of the plant and providing the dams and waterways to bring the water to the wheels. Within the last ten years the costs of labor and materials have practically doubled, but due to improvement in designs, water power is still able to compete with power produced in steam plants. In fact, low-head developments are now being made that a few years ago would have been considered uneconomical. Developments for heads as low as 8 ft. are being made in a way that for operating conveniences they compare favorably with medium-head stations.

One of the best illustrations of some of these improvements is obtained when an old setting is converted to accommodate a modern turbine as described in the leading article in this issue. In this case, notwithstanding the limitations placed upon the installation by the old setting, it was possible to increase the power of the turbine 60 per cent and obtain a 3½ per cent improvement in maximum efficiency. The penstock gives a rather peculiar combination of velocities compared with general practice, where the velocity is

gradually increased from the intake to the turbine. In the remodeled installation in question, the velocity of the water in the penstock is increased and decreased twice. At the intake the velocity increases to more than 17 ft. per second, then decreases in the main body of the penstock to nearly 12 ft., increases in the power house to more than 70 ft. and enters the scroll case at about 15 ft. per second at full load. All of these velocities are higher than are generally used and are all higher than for the older units in the plant.

The velocities in the draft tube are also considerably higher for the new machine than for the older units. At the discharge end the velocity is almost double, being 7.6 ft. per second for the new machine, compared with 4 ft. for the old units. Notwithstanding these apparently high water velocities, careful tests have shown that 87½ per cent of the energy of the water, represented by the gross head on the plant, is delivered at the busbars when the unit is loaded to its point of best efficiency. The efficiency curve of the turbine is fairly flat, being above 90 per cent between loads of 12,000 and about 16,000 horsepower.

Tests made on models in the laboratory showed the new draft tube to have 1½ per cent better efficiency and 10½ per cent greater power than obtained with the old-type tube. These model tests and the results obtained in practice show the necessity of obtaining a uniform distribution of flow in the draft tube. In the old draft tubes, although the average flow figures out a low value at the discharge, there are probably sections where the velocity is much higher than this and other sections where the water may flow back into the tube, causing eddies, which accounts for the lower efficiencies. If this installation emphasizes any one thing more than another, it is the necessity of avoiding abrupt changes of velocity in the water column, if losses in power are to be kept at a minimum. It is in the designing of the waterway to obtain smooth flows to and away from the turbine that a large part of the improvement in water-power-plant efficiency has been obtained.

Management or Labor?

THE men actively engaged in the operation of industrial enterprises are commonly grouped in two classes—*management* and *labor*. To which of these two groups does the operating engineer belong? Except in plants of insignificant importance he is certainly not "labor" as that term is commonly understood, since he directs the labor of other men, such as watch engineers, firemen, oilers, etc. If, then, the engineer cannot be classed under labor, is he part of the "management"? When one talks with the engineer one will generally find him referring to the management as "they" rather than "we." So it must perhaps be concluded that in the ordinary meaning of the terms the typical engineer occupies a position intermediate between "management" and "labor." He takes orders and he gives them.

Yet in a very real sense the engineer worthy of the name is a manager. Brains are a more essential part of his equipment than brawn or even manual skill, important as the latter is for emergency use. In most industrial plants the operating engineer has more need of initiative and independent judgment than the head of a manufacturing department, because the work of the latter is more likely to be understood and guided by the plant manager.

In those industries where power generation is an important factor, a broad-gage engineer can often make himself an outstanding figure—a man frequently called into the inner councils in matters of importance. This is particularly true of the so-called "plant engineer" found in many organizations, who is generally responsible for mechanical service throughout the factory as well as for the production of power, heat, refrigeration, etc. The full-fledged plant engineer may be a manager in a very real sense of the term, making himself a vital force in the guidance of an industrial organization.

Compressing Steam

THOUSANDS of engineers must have thought of the possibility of reversing the steam-engine cycle, using mechanical power to raise steam from a lower to a higher pressure. No important mechanical difficulties stand in the way. The real trouble has been to find a practical use for such a process.

In most cases it is preferable, both mechanically and thermally, to generate steam at a pressure not less than that required at the point of use, but there are exceptions to this general rule. Suppose, for example, that a large manufacturing plant requires quantities of heating or process steam at some moderate pressure and that the whole plant is piped for this pressure. If a small amount of higher-pressure steam is desired at some distant point for a special process, the cost of constructing and operating a separate high-pressure line may be so high as to justify installing a motor-driven steam compressor at the point of use. Such an arrangement, as described by Guy B. Randall in this issue, gives extreme flexibility of pressure control and a high thermal efficiency.

This question of thermal efficiency deserves a little thought. The best steam engine can turn but a small part of the heat energy of the throttle steam into mechanical work, but the exhaust contains all the heat at the throttle less only the heat equivalent of the power generated and the small external losses. In other words, although its efficiency is low as a power producer, the combined efficiency as power producer and heat furnisher is very high if the exhaust is utilized.

In the steam compressor the exhaust is fully utilized. The high-pressure exhaust steam contains all the heat in the low-pressure inlet steam plus the heat equivalent of the electrical input of the driving motor, minus the relatively small external losses in motor and compressor. A small amount of high-cost electrical energy added at high efficiency to a large amount of low-cost energy in the low-pressure steam makes the sum of the two available at a higher pressure and temperature.

The advantages of steam for oven heating are evident. Steam is essentially a constant-temperature heating medium. A kilowatt of electricity represents a constant flow of energy and may correspond to any temperature whatever, depending upon the resistance of surroundings to heat flow. A completely steam-jacketed oven, on the other hand, *must* come almost exactly to the temperature corresponding to the pressure of the steam, regardless of the amount of heat insulation on the outside.

The power engineer's job is to furnish power, steam, etc., when and where needed, and at minimum over-all cost. He will be interested in Mr. Randall's discussion of the steam compressor as an important aid in accomplishing this.

Practical Ideas From Practical Men

Pure Water for Turbine Glands

Soft cooling water for the glands of our main steam-turbine unit is obtained as follows:

A portion of the condensation returning from the heating system is diverted to a tank in which a float valve maintains the water level. As it comes to the tank, this water is too hot to use on the glands, so it is cooled by passing it by gravity through a pipe coil submerged in the cold well of the condenser. From this coil the water is piped to a small centrifugal pump and is circulated through the glands, oil cooler, etc., back to the tank to complete the circuit. Little makeup water is required and little attention called for.

This apparatus has been in use more than two years and works well. P. L. WATERS.

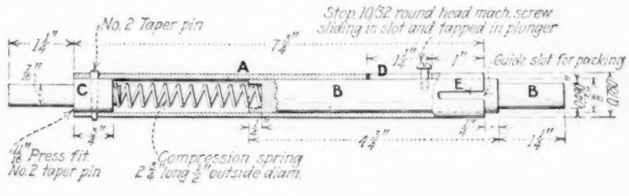
Elgin, Ill.

A Semi-Automatic Surface Condenser Tube Packing Tool

The illustration shows a handy and time-saving tool we use for repacking our condenser tubes with the ordinary "corset lacing." While the idea is not original, it should prove of interest to many engineers.

Our condenser, which is of the surface type, is fitted with standard $\frac{5}{8}$-in. bronze tubes. The dimensions of the packing tool illustrated are for this size of tube.

The tool consists of a sleeve *A* made from a piece of standard $\frac{1}{2}$-in. steel pipe approximately 7$\frac{3}{4}$ in. long, bored and reamed out to $\frac{5}{8}$ in. inside diameter to permit of the insertion of a plunger *B*. At the opposite end a plug *C* is driven into the pipe and held in place by a No. 2 taper pin. The outside of the pipe is turned at one end to a diameter suitable for insertion into the tube packing space, and in this finished end two slots are cut as shown at *D* and *E*, which serve respectively



Details of packing tool

as a guide for the stop screw in the plunger and as a guide for the packing.

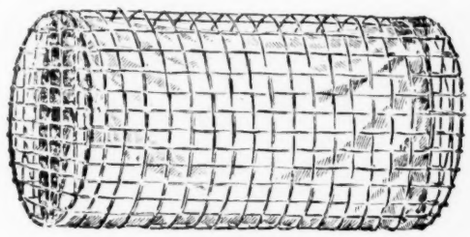
In packing the tubes, the tool is held in an ordinary carpenter's brace and the end of the plunger *B* inserted into the tube. One turn of the corset lace is now wrapped around the plunger and pushed home, and then, by rotating the tool and using a light pressure, the length of packing is all screwed into place. A little linseed oil should be used to lubricate the plunger, and if the tool is carefully made it will be found that the condenser tubes can be packed quickly. Of course the tube ends should be in good shape before beginning the packing operation, and any burrs should be removed with a smooth file and all "necked" or out-of-round tubes discarded. GEORGE WOOD.

Brooklyn, N. Y.

Sack in Boiler Caught the Scale

In looking over some old records I came across an old advertisement for a simple device called "Holcomb's Automatic Boiler Cleaner." The idea originated in my home town, and although I believe the practice of using this device may be dangerous, it was followed for some time in places near by.

It consisted of a canvas sack supported by a wire basket, as shown in the accompanying sketch. Two such cleaners were inserted in the boiler, one on top of the tubes and one below, the open end being pointed against the direction of flow of water. This skimmed the scum off the water and deposited it in the sack,



Sack in wire basket kept boiler clean

which was removed and cleaned periodically. This device was used in the flour mill where it originated and in the water-works and various other places near by. Although the sack collected a large amount of scale and water impurities, the idea does not seem to be good engineering. It never saw widespread use and the company which pushed it soon failed.

The inventor was a resident of Stanton, Mich., at the time he conceived the idea. This city was at that time a "has-been" lumber town, most of the timber having been cut off, and agriculture was just establishing itself. Flour mills were built on or near sites of lumber mills, and as there was no water power, steam power was resorted to.

As Stanton is in a district of very hard water, cleaning was necessary at frequent intervals. In cleaning a boiler in the mill one day the engineer happened to close the boiler, leaving a pair of overalls on top of the tubes. After running for a long time, he again opened the boiler for cleaning. He soon noticed that there was very little scale on the tubes, and investigation disclosed the overalls lying on the tubes and full of scale. After this he improved upon this discovery by using the wire basket so as not to allow the sack to settle onto the tubes. Soon afterward he quit his place and interested

others to the extent that he was able to form a company to manufacture and distribute the device. Seeing this advertisement brings back memories of old days and devices that have come and gone after little or no widespread use because they proved to be dangerous, although effective. FREDERICK PAKES.

Greenville, Mich.

Laying a Water Pipe Under Difficulties

Several years ago I was engaged to redeem a waterworks in a city of about 12,000 population, located in the Northwest. The water system was only two years old, but it was a wreck financially and mechanically due to having been in the hands of incompetent management.

The power equipment consisted of two 2,000,000-gal. high-duty pumping engines and a battery of boilers. The pipe system consisted of 15 miles of main ranging from 14 to 4 in. in diameter, and supplying less than 1,000 customers. The pumping equipment was in deplorable condition and had to be thoroughly overhauled. After weeks of hard work overhauling the machinery and checking and adjusting the valves to get the best economical service, we had the plant back in good operating condition.

We then turned our attention to the boilers. We ran an 8-hour test to see what efficiency was being produced, as the boilers were entirely too large for the load and the settings and furnaces were in bad shape. The best we could get was around 50 per cent. After giving them a thorough overhauling and reducing the grate area about 40 per cent by covering with firebrick, we obtained 72 per cent efficiency.

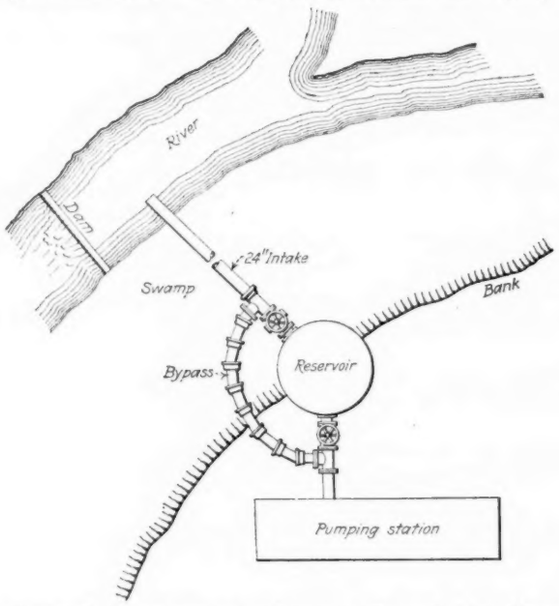
Having put the power end in good shape, we went after the pipe system, checked all valves and fire hydrants, repaired all leaks in the mains and also a great many fixture leaks which we found by a house-to-house inspection. It was evident that unless we could get more consumers or a higher rate, the plant would not be a financial success.

The town had a body of good sheet water about 25 ft. below the surface, and it was quite a task to get the people to give up their wells, but by showing them the dangers they were running from contamination of their water supply and by taking over the running of the services from the main to the property line, charging them cost plus 10 per cent, we greatly increased the number of consumers. At the time we took over the management of this plant there were no records to show where the money came from and where it went. So we introduced a system of bookkeeping and in less than one year the plant was a paying proposition.

The pumping station was located about 300 ft. from the river and received its water from this source. The water came through a 24-in. pipe to a large receiving reservoir and settling basin close to the plant. The land between the reservoir and the river was a swamp composed principally of quicksand. When the plant was designed, no provision was made for cleaning the reservoir. It had been customary up to this time to close the intake valve located close to the reservoir, pump out the reservoir, shut down the pump and leave the city without water for about 8 to 10 hours each time it was cleaned. We decided to obviate this periodic shutdown by putting a bypass around the reservoir. As the valve in the intake had been put too close to the reservoir to allow a 24-in. tee to be inserted between the valve and the reservoir, to provide for a bypass some way had to be devised to cut off the flow in the intake pipe while the work was being done.

We constructed a large ball of burlap and tied it with 1¼-in. manilla rope so that when it was placed in the line it would cut off the flow from the river. We then constructed a cofferdam around the pipe where we wished to insert the tee, and got all the necessary tools, pipe and fittings ready for the job. Two men took the ball in a boat to the inlet end of the pipe and sank it down until the force of the water carried it into the pipe. We had a man on the bank with the rope snubbed around a tree and we were careful not to give the ball too much slack, as we were afraid it would snap the rope. When the ball went into place and the slack of the rope was taken up, the flow of water was completely shut off. We then cut the pipe and inserted the tee and laid enough pipe to get on solid ground.

The job took several hours longer than we had expected, as about 50 per cent of our work was to keep the men from being submerged in the quicksand that would constantly come in through the cofferdam. When the job was done and everything seemed all right, we



General arrangement of reservoir and pipe lines

went to the river and released the rope. The ball and rope went down the pipe like a shot, but when it came to the tee it stopped and wedged solid.

We were all worn out fighting the quicksand, but the ball had to come out before we could start up the pumps. So we welded a 1¼-in. augur to the end of a 1-in. pipe and forced it into the ball from the reservoir end of the pipe. Then we pulled on the end of the pipe with a block and tackle. Each pull would bring a part of the ball and finally the water and ball came roaring into the reservoir.

When it was proposed to the owners that a bypass be put in, they said it was impossible, as the river end of the pipe was 8 ft. under water and at the reservoir end, where the tee was to be inserted, it was in 10 ft. of quicksand. The pipe had been put together on pontoons and lowered into the swamp. The first attempt at plugging the pipe was a failure, as we were not careful enough in snubbing our cable and it snapped when the weight came on. W. J. LAPWORTH.

Pittsburg, Kan.

Comments from Readers

Return Trap vs. Steam Pump for Boiler Feeding

The remarks made by Andrew F. Sheehan in the Jan. 19 issue on the poorer economy of using return traps instead of a steam pump for boiler feeding are entirely correct. In a general way the problem is the same as injector vs. steam pump. If the feed water is hotter it is at the expense of live steam heating, which is uneconomical in most cases, as exhaust from some source is usually available.

Another side of the question, which Mr. Sheehan did not touch, is the selling of roughly built and poorly lubricated tilting traps for service requiring the high degree of reliability and continuity of operation of boiler feeding. Boiler-feed pumps are usually installed in duplicate, but do you hear the trap advocates advise this? No. Tilting traps have much greater weight than a steam pump, on bearings and large packed joints to be accurately aligned and guided, but in most cases the bearing surfaces are poorly arranged, none too adequate in area, without provision for continuous lubrication or taking up wear. Also, owing to the multiple function of the valves it is much more difficult to diagnose troubles than with a steam pump where each part has its own function and their operation can be more readily checked. Further considerations against such use are that for equal overload capacities the trap will usually cost more than a steam pump and must be located in a rather inconvenient and often uncomfortable and inaccessible place above the boiler instead of on the floor beside the boiler and directly under the fireman's eye.

New Haven, Conn. H. D. FISHER.

Perkins Boiler

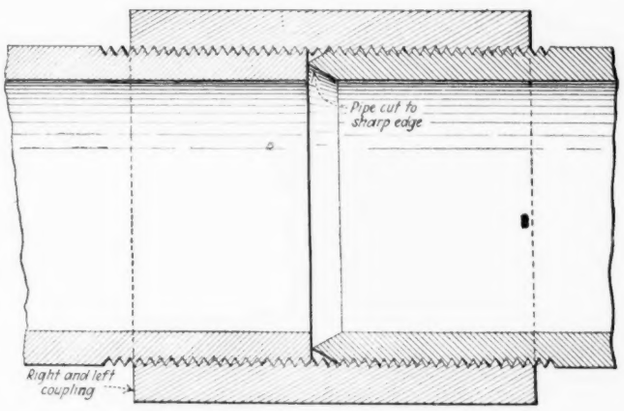
Power recently had an interesting article on Jacob Perkins'[1] high-pressure boilers. The boilers consisted of coiled pipes, if I remember rightly, working at pressures of about one thousand pounds per square inch. This type of boiler is still used in the United Kingdom at the same pressure for heating railway-station waiting rooms and in certain institutions with hot-water heating.

No mention is made of the style of joints used, a most important point. I inclose a drawing of the kind we used on railways for this style of boiler.

The end of one pipe was faced flat, and the end of the other pipe faced to a V edge as shown in the sketch. These were faced up with small milling cutters, held by a guide that screwed onto the end of the pipe; cutters were turned by hand with a ratchet. The joints were metal-to-metal, no paint or jointing material being necessary.

I have never known this type of joint to leak when properly faced up and the pipes square with each other, the only objection being that the joints have to be recut every time the pipes are taken apart.

The threads used had to be mongrel ones, of course, 12½ or 13½ threads per inch, and screwed parallel all the way, one being screwed right-hand thread and the other left-hand thread, a right-and-left coupling being used.



Type of joint used for high pressures

The best results were obtained when different pipe circuits were led back to the boiler separately, each having its own heating coil.

An expansion tank containing the lever safety valve and water-supply pipe was always located at the highest point.

The circulation was good when the pipes were properly graded, a flow and return being necessary. Great care was required, as the circulation would stop completely if the pipes got air locked; in this case the coils in the boiler would form steam and burn and burst.

The coils of the boiler were in the form of a hollow square, with the fire-bars on the bottom. Coke was put in through a hole in the top of the boiler brickwork.

O. G. A. PETTERSSON.

Vancouver, British Columbia.

[1]The March 10, 1925, issue of *Power* described Jacob Perkins' experiments with unaflow engines in 1827. His steam generator was described in the March 24 issue.

Oil-Engine Piston Freezing

An item on page 928, of the Dec. 15, 1925 issue, suggests, as I have for some time appreciated, that the importance of proper heat transfer from the piston and cylinder of an oil engine, or for that matter any internal-combustion engine, is not appreciated by many operators.

Not only should the circulation of the cooling water be maintained after shutting down the engine, but the engine, after having the load removed, should be run with no load and at reduced speed until there has been a decided drop in the temperature of the cooling water, exhaust gas and lubricating oil. The greater the temperature reduction in this manner the better for the

engine. The time taken to so cool the engine can be noted and established as a matter of routine, the same as warming up is a matter of routine in a properly conducted plant.

Of course, when an engine so cooled is stopped, the cooling water should be kept circulating until there is no appreciable temperature rise through the jackets. The primary object of thus cooling the engine is the maintenance of a good oil film between all working metal surfaces for as much of the cooling period as is possible. It also insures a gradual and even cooling to a reasonable temperature of the most highly heated parts, and an accompanying reduction of stresses and distortion. If this process is consistently followed when shutting down an engine, the liability of freezing will be reduced, if not eliminated entirely.

It will also be found that some other troubles that are considered inherent in this class of engine will be greatly reduced, such as warping, burning, pitting and sticking of valves; carbonization, gumming and loss of "life" of piston rings; the tendency so noticeable in some cases to "knock" on first starting; excessive wear on cylinder walls, piston skirts, rings, pins and piston-pin bearings.

I am sure that any time involved in establishing this process of stopping as a matter of routine will be amply repaid by reduced maintenance.

Devon, Conn. L. A. PIERSON.

Welded Pressure Tanks

Referring to the letter by E. E. Thum, the chances are that Mr. Thum himself would hesitate before accepting welded pressure vessels after having had experiences with them, similar to those which I have had.

For a few years I was associated with a company that manufactured refrigerating equipment in which pressure vessels were used—the pressure going up to the maximum of about 175 lb., as stated in my former letter in *Power*. The inventor did not inform our company that several of his previous installations had exploded, in one instance five people being killed as a result. All the vessels were welded, either electrically or with gas. Welding was considered necessary because it insured tightness, whereas riveting permitted leaks, and ammonia leaks are decidedly annoying.

After my connection with the company larger pressure vessels were installed—some of them three feet and more in diameter. If I remember correctly, some were four feet in diameter. None of these exploded in the sense that there was any violence of disruption, but in two installations the seams parted, causing much confusion, loss of time and expense. After the installations were completed, the system was abandoned by both owners—not alone because of the possible danger, but because the system itself was inefficient and uneconomical and they could not compete with other systems of refrigeration. This latter, to be sure, has nothing to do with the safety of welded tanks.

During the summer of 1924 one of the generators of this system exploded at Hotel Pines, Metuchen, N. J., killing the engineer. The generators and receiver used in the Hotel Pines installation were electrically welded. I have been informed that the state officials of New Jersey decided that poor welding was the cause of this explosion. I believe that a first-class, intelligent engineer in charge of the welding would have averted the explosion. I do not want to create the impression that all welded pressure tanks are not good. They are good when the welding is done properly—by individuals or concerns who understand the welding business and who do it as it should be done.

Possibly one of the reasons why the seams in the aforementioned generator weakened and failed is the fact that in the intermittent system of refrigeration the vessel is first subjected to a pressure of 175 lb. while it is heated to the corresponding temperature of aqua ammonia. Then it is suddenly cooled with cooling water and the stress changes gradually to a compressive stress because of a vacuum within the generator. This alternate cooling and heating and compression and tension is a severe test for any joint and is the reason why riveted joints could not be made to hold satisfactorily without leaking. In the tests cited in Bulletin No. 5 of the American Welding Society, it happens that the stresses were purely tensile and there was no alternating from tension to compression as in the instances cited.

I am not opposed to welding so long as it can be assured to be at least as safe as riveted joints. The personal equation has been well removed in the case of riveted joints, but not in welding operations, so far as I know. My motive in writing these letters is principally to urge caution and to tell about failures that have occurred, so that others may benefit thereby. There is no reason why we should not tell about our failures. W. F. SCHAPHORST.

Newark, N. J.

"Writing Yourself to the Fore"

In his letter entitled "Writing Yourself to the Fore" in the Dec. 29, 1925, issue, C. M. Durgin puts the query, "How can it be done?" and then gives a long list of stumbling blocks to be found on the pathway of the young engineer anxious to get ahead, all of which may become stepping stones, if one possesses initiative and confidence in oneself. Some thirty years ago, when at the bottom of the ladder, I began "writing myself to the fore," and since that time I have experienced practically all the stumbling blocks mentioned by Mr. Durgin, but the result has been a gradual climbing of the ladder, many happy hours in writing, many friends scattered all over the world, some financial gain, and last, but not least, a higher standard of independence.

During this time I have looked at the problem from various angles, and long ago concluded that the main reason of failure of our young men at "writing themselves to the fore" is because they will not read. To accomplish any success, however small, as a writer, he must change his outlook and read consistently. By doing this any young man of ordinaray intelligence can attain a certain degree of success as a writer, and after a little experience the objections put forward by Mr. Durgin will disappear.

If your employers wish to censor your efforts, by all means put them forward, and should they fail to pass, look at them through your employer's glasses and you may then find he is right, in which case you must try again, keeping away from his secrets which he pays you to protect. If you think malice and nothing else caused the objection, strike out on a different line entirely, and using a pen name write of the things

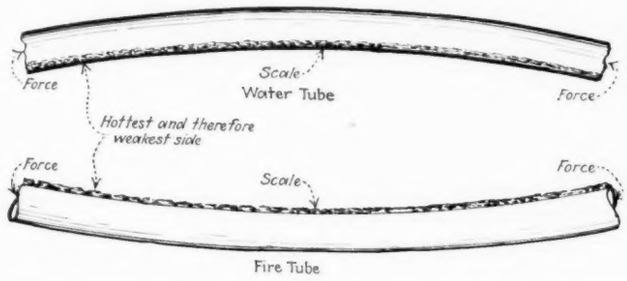
you saw and did before attaching yourself to this firm, and what you hear and see outside your actual employment, and for practice and experience write up actual incidents of your employment, putting them aside for future reference. Some twenty years ago I was employed by a firm that objected to anyone writing for the press. Soon after starting, I made improvements to an air compressor, and having a strong desire to pass this on, I wrote a description of these improvements as they would be applied to a hydraulic accumulator, and sent it to an editor, and in due course it was published. The old man, on seeing this, soon came round to inform me of this, and having used a pen-name, he had no idea of its source and explained "that someone must have seen my idea." "Yes!" I said, "he'll also get half a week's wages for doing it." This made an impression upon the old man, and very soon I had permission to write upon anything connected with our plant, and before leaving I wrote a description of the works, for which the old man supplied the photographs and a little later added a five-pound note to the sum I received from the editor.

Since that time, when applying for a position, any writings of mine dealing with the work in view are put forward as references, always to my advantage, and I know of no position that could legitimately debar one from writing. If not of your present work, then of the past or future. F. P. TERRY.

Belfast, Ireland.

Buckling of Boiler Tubes

I read with interest the letter by W. Harris Day in the Jan. 5 issue on the "Buckling of Boiler Tubes," in which he states that boiler tubes buckle because of unequal expansion under the influence of intense heat. But he does not explain why tubes in water-tube boilers of the horizontal type buckle upward and why those in the fire-tube type of boiler buckle downward. In the accompanying illustration I have endeavored to show exactly why the buckling is in opposite directions.



Illustrates why tubes of fire-tube and water-tube boilers buckle in opposite directions

When the steel of which boiler tubes are made becomes heated, it naturally weakens, and therefore the hottest side is the weakest side. In the water-tube boiler the weakest side is on the bottom. The forces acting on the tube when in operation are compressive forces and are equal and opposite in direction, acting from the ends parallel with the tube. The hottest side compresses more readily than the cooler side, and therefore in the case of the water-tube boiler the buckling is upward.

For the same reason the upper side in the fire-tube boiler is the hottest, and therefore the weakest side, consequently the buckling is downward.

If the buckling were caused solely by the expansion due to the difference in temperature on the two sides—that is, if there were no change in strength—the buckling would be in the direction opposite to that stated by Mr. Day and opposite to that shown in the illustration. Mr. Day says that the buckling is "always in the direction of least resistance." That, of course, is true, but would it not be clearer to say "The hottest, and therefore the weakest side, always becomes concave"?

A study of the theory of columns will explain fully why buckling is always such that the hottest side becomes concave. W. F. SCHAPHORST.

Newark, N. J.

Charging Refrigerating System with Ammonia

With reference to the inquiry in the Jan. 5 issue on what is the best procedure to follow in putting the initial charge of ammonia into a refrigerating system, my method of doing this is as follows:

First, shut the master expansion valve and open the valve between the condenser and receiver, also valves between condenser and coils. Next, see that water is in the condenser. Then open the discharge valves and start the machine, then slowly open the suction valves. Previous to starting the machine, connect an ammonia drum to the charging connection. After making sure that all the connections are tight, open the charging valve wide, then gradually open the valve on the drum head. As the drum empties out, a frost will appear on the drum, and when this frost is all gone the drum is empty. R. G. SUMMERS.

Rochester, N. Y.

Coal as a Public Utility

In reading your editorial captioned "The Coal Strike" in the Feb. 23 issue of *Power*, I am impressed with the fact that possibly several decisions of the United States Supreme Court concerning the question whether the mining of coal is a matter charged with public interest have not come to your attention.

I would refer you to decision of the Supreme Court in 262 U. S. 522, the Wolff Packing Co. vs. the Industrial Relations Court of Kansas, in which the court stated:

"It has never been supposed since the adoption of the Constitution that the business of the butcher, or the baker, the tailor, the woodchopper, the mining operator or the miner, was clothed with such a public interest that the price of his product or his wages could be fixed by state regulation. It is true that in the days of the early common law an omnipotent parliament did regulate prices and wages as it chose, and occasionally a colonial legislature sought to exercise the same power; but since the adoption of our Constitution one does not devote one's property or business to the public use or clothe it with a public interest merely because one makes commodities for, and sells to, the public in the common callings of which those above mentioned are instances."

You do not raise the issue in your editorial as to whether the mining of coal is interstate commerce. For that reason I presume you are familiar with the numerous decisions in which the courts have held that mining

is not interstate commerce and I shall not trouble you with the citation of these cases, which are not only numerous but also in my mind conclusive.

HARRY L. GANDY,
Executive Secretary,
Washington D. C. National Coal Association.

Boiler-Water Level Drops

Referring to the letter of G. Grow in the Jan. 19 issue, relating to the drop of water level in a heating boiler, it is clear that when the boiler was fired up with the steam-outlet valve closed a pressure was built up in the boiler.

If there was no check valve on the return line at the boiler, or if the check did not hold tight, the steam pressure would force the water through the return line and cause it to rise up in any unchecked drip or other lines which might be connected to the return. When the fire was drawn, of course the pressure dropped in the boiler and the water came back again.

We are asked to assume that when the day man came on duty, the steam valve was still closed. If this was so, it is just possible that the check valve on the return line, which previously had failed to close because of dirt or from some other cause, had cleared itself and was now functioning properly. On the other hand, it is more probable that in the confusion caused by trying to solve the mystery, either the night man or the day man opened the steam valve and then forgot that he had done so.

Of course if the steam valve was opened, pressure would come on the far end of the return line through the drips or other connections, making the pressure at the end of the line nearly equal to that on the water in the boiler, in which case the water previously forced up in the return riser connections would come back to the boiler and assume the proper working level.

Newark, N. J. J. O. G. GIBBONS.

Referring to the article, "Boiler-Water Level Drops," in the Jan. 19 issue, I believe that the statements of both firemen are correct. The boiler in question has a stop valve and therefore must have a check valve in the return. The night fireman closed the stop valve and started his fire. As soon as the pressure rose in the boiler, the water level began to drop. This would indicate that scale or some foreign matter had lodged under the check valve and was holding it open, allowing the water to leave the boiler.

The fireman pulled his fire, and in about ten or fifteen minutes the water returned, showing that the steam had condensed. This happened several times until the day man came on the job. When he started the fire, not having made any changes, nothing unusual happened, which would prove that the water in passing back and forth had cleared the valve, allowing it to close.

Lowell, Mass. J. O. BURMAN.

There is hardly sufficient information given in Mr. Grow's letter to give an intelligent answer to his query. If the day fireman did not make any change whatever to the boiler or valves, but proceeded to operate the boiler just as the night man had left it, there is only one way that the water could leave the boiler and that is through the returns. To avoid further trouble of this kind, it would be well to examine the check valve in the return line and make it work freely or renew it. Better still would be to install what is called a checkless return, which is being adopted by many engineers.

Uniontown, Pa. C. B. BAILEY.

Twelve Hundred Pound Pressure Boiler Plant

The article on the 1,200-lb. boiler and turbine plant at Weymouth, Mass., published in the Sept. 15, 1925, issue, has proved of great interest to me. That the step is in the right direction and that theory approves of such an increase in pressure may readily be granted. However, I am inclined to believe, from experience in boiler design and operation, that the design chosen for this work is open to some objection.

The boiler is fitted with 2-in. tubes, apparently about 17 ft. long, with an inside diameter of about 1.6 in. It seems to me that the circulation will be insufficient to keep these tubes from overheating.

Experience with boilers of the Yarrow and Thornycroft types shows that a vertical tube 1¾ in. in diameter and only 7 or 8 ft. long will burn out. In these boilers the tubes are expanded into a comparatively large drum full of water. It is my belief that in a smaller tube, in a nearly horizontal position, the velocity will be slow, with the result that steam slugs will form and momentarily stop water circulation, resulting in the burning out of tubes. In operation this could be reduced only by lowering the boiler capacity.

Another source of difficulty, in my opinion, is in the numerous handhole caps. With such high pressures a tight joint is indispensable—not approximately tight, but 100 per cent tight. In making up the number of joints necessary for this boiler and keeping them tight under 1,200 lb. per sq.in. pressure I believe that operating difficulties are invited which seem entirely unnecessary.

In a boiler operating under such conditions, it is presumed that the feed water will be distilled and that scale formation in the tubes is exceedingly remote. This does away with the necessity for handholes for inspection and cleaning.

The drum design of this boiler is exceedingly good, and the method of manufacture should produce a perfect job in every way. The makers of this drum say that it is actually easier to make drums with heavy than with lighter walls. These drums are formed from the solid ingot and turned and bored to the thickness desired. Under forging pressure the metal will be sound in every way; any flaw, if such a thing were possible, would be squeezed out and the machining would disclose any imperfection.

The possibility of making a drum perfect in every way facilitates the use of a boiler without small tubes and numerous joints and handholes. Such a boiler is simpler and cheaper than the header type.

It seems to me that the boiler of the future for high pressure will be of the drum type. This type is coming to the front in Europe, for pressures of 400 lb. per sq.in. and higher.

In designing a boiler for 1,200 lb. working pressure, it seems to me that the smallest tube should be not less than 3 in., with an inside diameter of 2½ in., and I believe that in a boiler of the drum type tubes of that size will give perfect circulation.

Philadelphia, Pa. PHILLIPS BADENHAUSEN.

Factors Governing the Purchase or Generation of Power*

By W. A. Shoudy

WERE it not for the fact that generating costs are only a part of the cost of producing central-station power, few factory power plants would be justified. As the situation stands today the question before the factory management is not "Can we afford to purchase power?" but "Can we afford to generate power in our own plant?"

This question is not readily answerable nor is it possible to lay down any formula applicable to every problem. There are some general classifications that can be made but when the right classification is found the class merely tells whether we can arrive at the answer by rule of thumb methods or whether only on elaborate engineering survey will be necessary before an answer can be found. An isolated plant is built for one of two reasons:

1. Because satisfactory service cannot be obtained from a local utility.

2. Because power can be generated at a total cost less than the estimated bill of the local utility.

Satisfactory service can generally be obtained today from the public utility except in some of the remote districts but if such service cannot be obtained the owner must build his own plant regardless of the cost of generating power.

When the problem becomes that of comparing the cost of private with purchased power, the following items must be considered:

1. Use factor (and at times load factor).

2. Fixed charges, covering interest on investment, depreciation (including amortization, etc.), insurance, rental and taxes.

3. Operating costs, including fuel, repairs, labor and miscellaneous.

Use Factor — The hours of useful work one gets from the plant has a decided bearing on the cost of operation both on account of fixed charges and upon the cost of maintenance or repairs but in a reverse direction. The ratio of the average load (for 8,760 hr.) to the capacity of the plant is the use (or capacity) factor. The higher this factor the lower will be the fixed charges per kilowatt-hour or horsepower because these charges will be spread over a larger output. The cost of repairs, however, will increase with an increase of use factor because the equipment is driven harder and longer and at times repairs must be made at overtime rates and sometimes without time for a thorough and lasting job.

Interest—This item is generally the rate which one must pay for money. If we must borrow the money the rate is easily determined but if taken from surplus we must use the rate that this would earn if left in the surplus. If it is necessary to take the money from working capital the rate of interest may be high.

Depreciation — Much has been written on this subject but for the purposes of this paper one may use the inaccurate definition as that annual deposit in the bank which will give back our capital when the plant is no longer of use. On the basis of such a loose definition one must estimate the years life expected and when possible when it will become inadequate for the needs. Such estimates are always inaccurate and must therefore be left to the business judgment of the management. Differences of opinion on this then may sway the choice sometimes either to purchased or generated power.

Taxes, Insurance, Rental — These items are determined by local conditions. The first two are easily determined but rental is often lost sight of. The installation of equipment in a vacant building does not mean that the building is obtained for no cost. If the equipment is not installed the building should be sold or rented; to use it for power means that rent is lost unless charged to power. A fair rental should be charged even if only a nominal amount can be justified.

Operating Charges—A more detailed subdivision of operating costs should generally be used, particularly after the plant has begun operation. Such detailed costs are of great help in improving plant operation but for advance estimate the briefer classification is generally sufficient.

Operating Labor—This item should include all labor on the regular operating payroll, both skilled and unskilled, necessary for the continuous operation of the plant. It should also include such labor for cleaning as is necessary and the occasional floating labor necessary for unusual coal or ash handling conditions. Supervision should not be forgotten and a portion of the plant office cost should be borne by power.

Repairs and Maintenance—These are always difficult to estimate and at best are seldom better than educated guesses. So much depends upon the type of service, the quality of apparatus and the intelligence of the labor and supervision. Repairs in a new plant should be low but inspection and maintenance should be begun at once or heavy repairs will be experienced after a few years operation. The mistaken policy of delaying maintenance often results in such heavy repairs in later years that the cost of private power becomes greater than that of purchased power.

Fuel—There is usually closer agreement in estimates of fuel consumption than in any other item. This is because one is dealing with factors that can be accurately calculated and about which much has been published. There is, however, one indeterminate factor, namely, the human factor in operation. The science of psychology has not advanced sufficiently to make it possible to prophesy what this factor will be. David Moffet Myers pointed out some years ago that the efficiency of any plant is the product of the efficiency of the machinery and the efficiency of the man running it. We can calculate the first; we can include banking losses and fuel for starting but we must divide this fuel rate by a factor less than one before we can tell the average fuel rate over a long period of time.

The public utility has other costs besides operating charges that must be met and it must make a profit or go out of business. If it were not for this fact no industrial plant could compete with the modern central station, because of the greater efficiencies possible with the larger central station equipment, unless the industrial power is a byproduct.

Byproduct Power

Substantially all factories have some need of steam for heating or processes. Even the smallest requires building heating. The latent heat is a large proportion of the heat absorbed in the boiler. It cannot be used for power but can be used for heating. In the majority of cases the factory plant is justified only when this latent heat in the exhaust steam is justified. The power then becomes a byproduct and is obtained at low cost.

The use of low-pressure exhaust steam for heating has been prevalent for many years but low back pressure is not necessary. One American rubber factory has for a number of years been operating a 5,000-kw. turbine exhausting at 80 lb. gage and using the exhaust in the vulcanizers. There are a large number of turbines so installed that steam can be bled from one of the upper stages. Such operating conditions increased the difficulties of the turbine design but it seems to have met with success.

Some of our industries, such as sugar refineries, some chemical works and some paper mills, have a greater demand for heat than for power and can therefore obtain all their power as a byproduct.

There are three main classifications based on fuel costs under which a factory is justified in generating its own power.

1. When power requirements are

*Abstracted from a paper before the Philadelphia Engineers Club, Feb. 16, 1926.

large and when sufficient condensing water can be obtained.

2. When the entire power can be generated as a byproduct power.

3. When, through co-operation of the factory and the utility, the entire steam or heat demands of the factory are used for the generation of byproduct power and the difference either purchased from or sold to the local utility.

The first two divisions have been discussed so frequently that it is unnecessary to further comment on them, but we are only beginning to study the third. It is a far more complex problem; one that requires not only expert engineering study but frank and open discussion with the utility. This third classification naturally subdivides into two parts:

1. Factories requiring more power than can be generated as byproduct power.

2. Factories that can generate more byproduct power than that required for their own uses.

The solution of the problem for the first subdivision is generally either by operating two boiler plants, one for heat and the other for power, or by purchasing all power and generating steam at low pressures. Such a solution is often the correct one.

If the excess requirements are small, little additional labor or investment is required beyond that for the process steam plant and the central station cannot compete.

If the excess power required is relatively large and the steam demands small, it is generally best to abandon power generation and build only a low-pressure boiler plant requiring minimum investment and supervision. The elimination of a power department, thus giving the management more time for other duties, is often a justifiable reason for not including generating equipment.

There is a broad no man's land between these sets of conditions, and in this field there is opportunity for considerable engineering study.

Plant Performances Compared

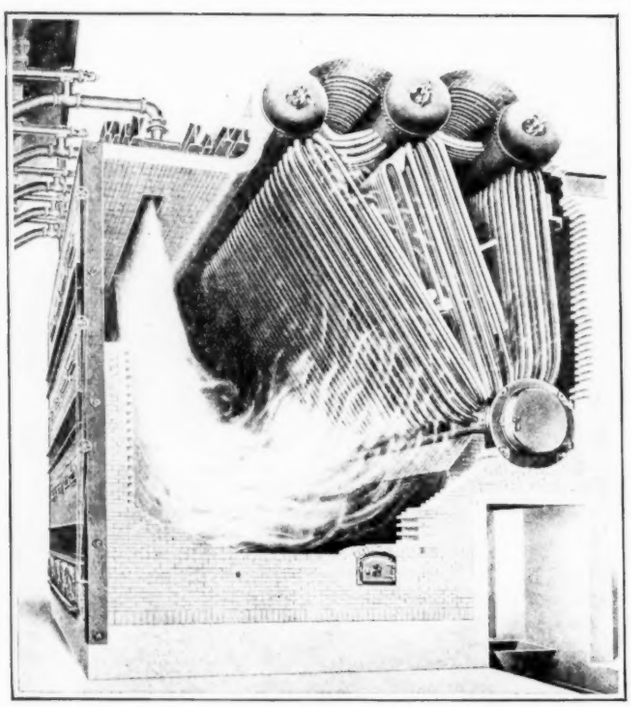
The best central station performance yet reported shows a kilowatt-hour produced for less than 14,000 B.t.u.. Rates of 16,000 to 20,000 B.t.u. per kilowatt-hour are about the average of the better stations. The industrial plant cannot hope to meet these records except through byproduct power. If all the process steam were used by plants for power generation, the excess power could be generated for about 6,000 B.t.u. per kilowatt-hour and at a less cost than it can be generated in the modern central station.

Industries owning and operating hydro-electric stations are today selling their surplus power to their local utilities and purchase their own shortages.

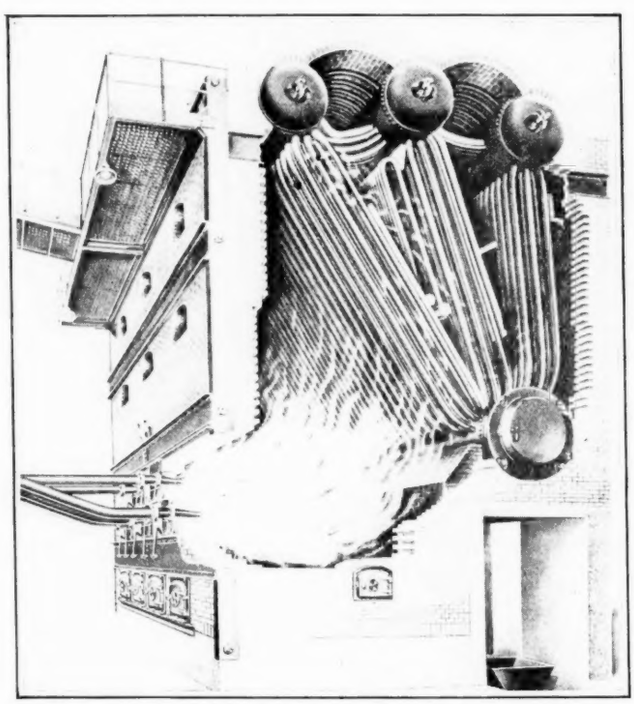
From the standpoint of economies any industry is justified in generating that portion of its power requirements which can be generated as a byproduct either of process steam or waste heat, as in cement mills. This does not mean that the factory will sell its surplus to the utility at the price it will pay when purchasing from the utility. The latter will probably own the connecting transmission lines and must meet the fixed charges on its investment and the line losses. The factory will be furnishing dump power and will probably expect firm power from the utility. The rate for the latter class must include the fixed charges on the equipment set aside to provide service to the customer, but if the interchange is purely dump power on both sides, closer rates will prevail.

The writer hesitates to offer this suggestion because of the possibility of misunderstanding. He does not believe that such arrangements can be made immediately but is convinced that in the larger industries such arrangements will gradually become effective. The size of both the industrial plant and the local utility will have an important bearing because the utility will only be interested in purchases that at least are a measurable percentage of their output. The industrial plant management must consent to operation in accordance with the rules of the utility operators and may have to employ some high grade men. They must both learn to talk and understand the same language, which after all is probably the only real stumbling block. The economies are there and they are worth striving to obtain.

Typical Vertical and Horizontal Methods of Firing Pulverized Coal



With pulverized anthracite, coke braise and low-volatile bituminous coals, vertical firing has been preferred by many powdered-coal operators. Opposition to stack draft during the first half of the flame travel necessitates jet velocities nearly 50 per cent greater than horizontal firing, so that resultant flame lengths vary from 19 to 25 ft., depending upon coal and other conditions. Heat releases per cubic foot of furnace volume with vertical firing seldom exceed 18,000 to 20,000 B.t.u. The ignition temperature of the carbon of coal will vary from 750 to 950 deg. F., whereas that of most carbon monoxide ranges from 1,190 to 1,220 degrees.



Horizontal firing has been preferred by many operators of pulverized-fuel plants burning coals containing 20 per cent or more volatile matter. Since the incoming jets of pulverized fuel and air do not oppose the stack draft during the first half of the flame travel, as with vertical firing, lesser jet velocities are permissible, resulting in flame lengths of from 14 to 16 ft., which, dependent upon boiler dimensions, often make possible heat releases as high as 25,000 B.t.u. per cubic foot of furnace volume, without excessive maintenance of the refractory becoming necessary.

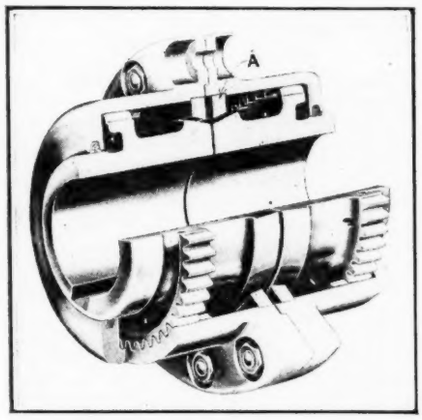
New and Improved Equipment

Poole Flexible Gear-Type Coupling

The flexible coupling of the gear type shown in the illustration has been brought out recently by the Poole Engineering & Machine Co., Baltimore, Md.

The coupling consists of two hubs, having an external gear on each meshing with internal gears in two sleeves which are bolted together, and two aligning rings *A* which are fitted in the sleeves.

To simplify the lining up of the



Flexible coupling of the gear type

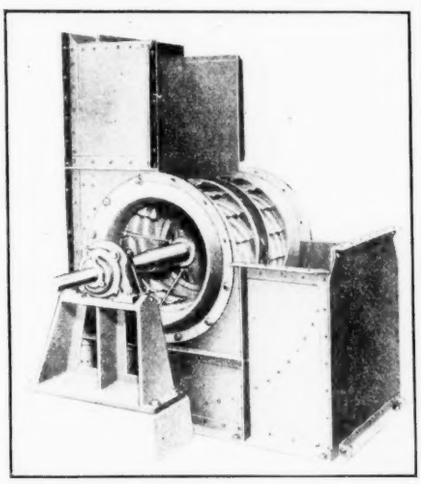
coupling, each hub has a tapered surface which in turn engages with a tapered surface on the rings *A* on the interior of each sleeve. When the sleeve is pushed back, the sleeve, hub and shaft act as a single unit and alignment is made by using a straightedge across the two flanges of the sleeves and calipers or thickness gages between the coupling faces.

To provide lubrication for the teeth when the coupling is running, a quantity of oil is poured into the coupling through oil holes provided in one side, and this quantity is sufficient to submerge the teeth when the coupling is in operation. The couplings are made in capacities ranging from 10.5 to 5,000 hp. per 100 r.p.m. and with bores from 1½ to 12 inches.

New Clarage High-Speed Blower for Forced Draft

A new type of high-speed blower designed for high economy over a wide performance range has been put out by the Clarage Fan Co., of Kalamazoo, Mich., for forced-draft service when direct connected to electric motors or steam turbines. A view of the new blower with a quarter section of the housing removed is shown. This blower is reported to have a maximum efficiency of 78 per cent and at from 60 to 140 per cent of normal rated capacity a mechanical efficiency above 70 per cent. Other performance features are the blower's self-limiting horsepower characteristic, which makes it impossible to overload the fan, and the development of a rising pressure curve which enables the blower to supply the air for peak loads, as at a constant speed an increased resistance results in but a slight decrease in air volume.

As indicated in the illustration, the blower has two single-inlet wheels of identical construction, each containing 16 blades pitched backward from the direction of air flow. Each blade is die stamped to insure uniformity of shape, thickness and weight, and is ribbed for greater strength to prevent distortion from centrifugal force. Each blade has three tongues of metal on one side and



New Clarage blower with quarter section of housing removed

four on the other, which are fitted into slots cut into the back plate and side rim, and are electrically welded in place. The wheel hubs are bolted and riveted to the back plates, and further strengthening is obtained by the use of tie rods running from hub to rim.

Fabricated from blue annealed, open-hearth steel, the blower housing is stiffened by bolting to an angle and channel-iron frame. As the housing is of the split type, a quarter section can be removed after installation for inspection of shaft and bearings.

To prevent excessive bearing speed, the ends of the shaft are tapered while the center is of larger cross-section to prevent deflection and to keep the shaft and wheels from reaching the critical speed.

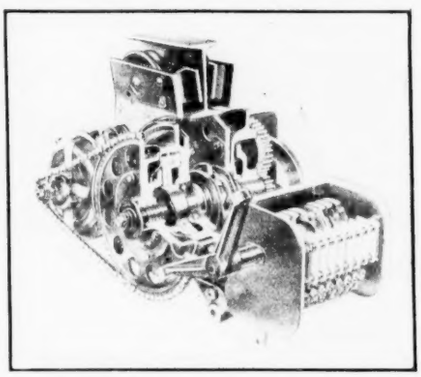
Grease type ball bearings with an Alemite attachment is a feature of the new blower. Mounted in special cases, these bearings have the self-aligning and height-adjusting features of the Clarage standard bearing. The ball bearing on the drive side is of the adapter type and carries radial load only, while the other bearing is of the plain type and carries both radial and thrust loads. The type of independent bearing supports used is indicated in the illustration.

Yale & Towne Electric Chain Hoist, Model 20-B

The Yale & Towne Manufacturing Co., Stamford, Conn., has recently extended its line of electric chain hoists by the addition of the model B-20, which is being built in capacities from ¼ to 2 tons and is designed to provide for close headroom, long lift, higher speeds and greater over-all strength than former models built by the company.

The suspension member of the hoist is centralized to give a balanced load on the trolley wheels and hoisting unit irrespective of the load position. The side plates of the trolley carriage can be spaced to fit the desired beam flange.

The hoist mechanism is inclosed in oiltight chambers and is readily accessible for inspection and repairs. The load sheave is carried on large chrome



Model 20-B electric chain hoist

vanadium steel ball bearings and is bronze bushed for the driving pinion, which is machined from a single drop forging and heat-treated. All gears, pinions and bearings are splash lubricated.

Chain containers can be furnished to hold any length of slack chain up to 60 ft. for the hoists up to 1-ton capacity and 30 ft. for the 2-ton hoist.

Loose pulleys in both cast iron and pressed steel, equipped with Timken roller bearings, are now being put out by the Dodge Manufacturing Co., Mishawaka, Ind. The steel pulleys are provided with an extra large hub to accommodate the bearing, whereas in the cast-iron pulleys the bearing is mounted in a housing, the complete unit being inserted in the hub. Special attention has been given to lubrication.

News in the Field of Power

Hearings on St. Lawrence Power Brings Out Statements by Both Smith and Young

State Engineers Challenge Cooper's Statement Regarding Costs of Public vs. Private Development—Governor Quotes Owen D. Young

THE statement of Colonel Hugh L. Cooper before the State Water Power Board on Feb. 25, as reported in *Power*, page 351, March 2 issue, that state development could be undertaken only at a double cost that by private interests has been challenged by friends of Governor Smith who cite the record of the Department of Public Works under Colonel Frederick Stuart Greene as proof that where there is a will there is a way of holding the cost of work done by the State down to approximately what the same sort of work would cost to private enterprise.

Engineers in the employ of the State, said that conditions had changed greatly since these contracts were made, and that today contractors could be found who would be willing to tackle even such a stupendous undertaking as the contemplated St. Lawrence River development was pictured to be by Colonel Cooper.

Governor Smith in speaking of the testimony brought out at the hearing before the State Water Power Board characterized the hearing as a "farce comedy" and at the same time made public excerpts from his correspondence with Owen D. Young, chairman of the Board of Directors of the G. E. Co. The whole letter, dated Feb. 9 follows:

MR. YOUNG'S LETTER

May I write you in order to make a contemporaneous record of my position on the water power situation as stated to you last evening. I desire this record not for the purpose of preventing misunderstanding between you and me as to my position, but so I may have it for the benefit of my associates in the industry who, of course, are deeply interested in the matter.

Please also understand that I am only undertaking to state my position, and not in any way to state yours or to indicate to what extent you agree or disagree with me.

1. I am in favor of the operation of the power business of the State of New York by private persons as distinguished from public officials, not on the ground of incapacity of personnel, but because I am satisfied that the same persons who now run our power business successfully would fail under the restraints and rigidity of a government bureau acting under limiting laws and in the face of political controversies.

2. The cost of energy developed from falling water is determined very large by the cost of the capital employed in the development. A public corporation such as you propose, whose securities would be exempt from taxation under the Federal law and under the state law, should produce, if properly set up, the required money substantially cheaper than a private corporation could obtain it.

3. I am opposed to the use of state or municipal credit for power development, transmission or distribution in any form or at any time, and, therefore, I should be opposed to the use by the public corporation above mentioned of state or municipal credit.

4. I see no objection, but, on the contrary, I can see some advantages, to the development of the great water powers on the St. Lawrence and in the gorge of Niagara by a public corporation rather than by a private corporation, and to the ownership of all lands, water rights, flowage, dams, power houses and structures by such a public corporation.

5. The public corporation in order to float its securities and to obtain distribution of such power, should make a contract with the private transmission and distributing companies of the state to undertake that distribution on terms that will yield them a fair return on the private capital employed in the business of that transmission and distribution. The question of amortizing the bonds of the public corporation and of amortizing the capital investment in the transmission and distribution system through a period of years is one of policy. If this amortization takes place rapidly, it will result in increasing the cost of power. If spread over a long period, it will not be a heavy burden on power users. If not amortized at all, but only maintenance, obsolescence, and depreciation are covered, power can be had for our existing generation at the lowest possible cost.

6. This I did not say to you, but I intended to. As to the small powers on our interior rivers, each watershed is a unit and should be dealt with as such so as to get the maximum use of the water of that particular watershed in the public interest. A watershed, like the Hudson, for example, has in it the question of flood prevention and navigation as well as the use of water for power. It is possible, and indeed I think probable, that the present corporation known as River Regulating Districts supply all the machinery that is necessary to protect the public. If not, there should be close co-operation, or possibly even unification of the river regulating district idea with your Water Power Authority.

Thanking you for the privilege of discussing the matter with you on your invitation, I beg to remain yours very respectfully.

OWEN D. YOUNG.

The Governor had quoted only paragraphs two and four. After he had made the letter public last night Mr. Young said that he felt further comment was unnecessary.

Electrotechnical Commission Meeting Plans

From April 13 to April 22 an annual plenary meeting of the International Electrotechnical Commission will be held in New York City at the Engineering Society Building. This will be the first time that this body has held its meeting in the United States. This commission was conceived in St. Louis in 1904 and was organized at London in 1906 in large part through the efforts of Dr. C. O. Mailloux of New York City. The original secretarial organization, with C. Le Maistre of London in charge, has functioned ever since, but the scope of the commission's work, at first confined to the technical details of strictly electrical engineering, such as the definition of terms and the encouragement of efforts to establish international definitions of basic units, has been broadened to include such subjects as the testing and rating of apparatus not only in the strictly electrical field but also in the field of prime movers for electrical plants.

In 1924 the World Power Conference referred to the commission the task of formulating an international agreement for the uniform measurement of water-power and the standardization of water-power and river-flow data, and this work will be taken up this year under the advisory committee meetings shown in the accompanying table.

The preliminary and incomplete list of delegates includes the following:

Belgium—Frans Dupont and M. E. Uytborok.

France—J. J. Frick and M. E. Roth.

Germany—P. Schirp, Dr. Rudenberg, P. Strecker, Dr. Fleischmann, M. Kloss and Richard Stern.

Great Britain—Sir Richard Glazebrook, Sir Archibald Denny, L. B. Atkinson, W. W. Lackie, L. St. L. Penched, Col. F. T. Purves, C. P. Sparks, Sir George Sutton, W. B. Woodhouse, S. T. Allen, E. G. Batt, S. B. Donkin, A. R. Everest, A. D. Cramb, P. V. Hunter, J. P. Gregory, W. Lee, Lieut.-Col. F. A. Cortez Leigh, R. B. Mitchell, W. Pearson, J. S. Peck, C. Rodgers, T. Roles, F. Wallis and P. Good.

Holland—C. Feldmann, Mr. Tromp, Mr. Rosskopf and Bellaar Spruyt.

PRELIMINARY PROGRAM FOR NEW YORK MEETINGS OF I.E.C. ADVISORY COMMITTEES

Time	Tuesday, April 13	Wednesday April 14	Thursday, April 15	Friday, April 16	Monday, April 19	Tuesday, April 20	Wednesday April 21	Thursday, April 22
Morning, 9.30 to 12.30	Opening Meeting.	Hydraulic Turbines. Rating.	Hydraulic Turbines. Rating.	Hydraulic Turbines. Transformer Oils.	Hydraulic Turbines. Transformer Oils.	Hydraulic Turbines. Traction Motors.	Prime Movers. Terminal Markings.	
Afternoon, 2.30 to 6.30	Experts' Papers on Rating.	Hydraulic Turbines. Rating.	Hydraulic Turbines. Rating.	Hydraulic Turbines. Transformer Oils.	Hydraulic Turbines. Transformer Oils.	Hydraulic Turbines.	Prime Movers. Terminal Markings.	Committee of Action.
Evening.	Nomenclature (Vocabulary).	Rules and Regulations.	Standard Pressures.	High-Pressure Tests.	High-Pressure Tests.	Lamp Holders and Caps.		

Italy—G. Semenza (president I.E.C.), E. Morelli, Mr. Ucelli and Ernesto Vannotti.
Norway—H. A. Mork.
Russia—Prof. Chatelain.
Switzerland—E. Huber-Stocker, A. Huber-Ruf, Charles Burlet, Antoine Schran, H. Zoelly and Paul Thut.
Poland—C. Drewnowski and Z. Okoniewski.
Spain—A. Artigas.
United States—W. F. Durand, F. R. Low, C. O. Mailloux, A. E. Kennelly, C. E. Skinner, F. D. Newbury, E. A. Snyder, A. H. Moore, J. Franklin Meyer, C. A. Bates, N. W. Storer and D. W. Roper.

The meetings will be followed by a tour leaving New York on April 23. The delegates will visit Philadelphia, Washington, Pittsburgh, Chicago, Detroit, Niagara Falls, Ottawa, Montreal, Boston and Schenectady, returning to New York May 5.

Petroleum Production During January Decreases

The production of crude petroleum in the United States for January, as reported to the Bureau of Mines, amounted to 59,656,000 bbl., a daily average of 1,924,000 bbl. This represents a decrease from the previous month of 42,000 bbl., per day, or 2 per cent, but is slightly higher than the production of a year ago. However, it is of interest that 32 per cent more oil wells were completed in Jan., 1926, than in Jan., 1925.

University of Illinois Has Research Assistantships

The College of Engineering and the Engineering Experiment Station at the University of Illinois, Urbana-Champaign, Ill., maintains fourteen research graduate assistantships. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $600, are open to graduates of approved American and foreign universities and technical schools. Nominations to these positions are made from applications received by the director, M. S. Ketchum, each year not later than the first of April. Additional information may be obtained from the director at the above address.

Mr. Ford Buys an Old Power Boiler

Announcement comes in the daily newspaper from Savannah, Georgia, that a relic of former times from this locality is to be included in the museum of Henry Ford. An old boiler made about 1850, which was discovered on Richmond plantation, a part of Mr. Ford's Bryan County plantation, when Mr. Ford and his party visited the place during the third week of February, was the article which attracted the attention of the manufacturer and collector of old industrial relics.

The boiler was used long ago to furnish power for an ancient rice mill. The mill was burned about forty years ago, it is said. The boiler has no flues and was made to be fired with rice straw. In reality, it is stated, it consists of a single container about 30 ft. long. Mr. Ford a few years ago purchased a locomotive of early manufacture in this same locality.

Tibet Power Plant Destroyed and Convoy Murdered

The *London Daily Mail* reports a massacre of a party, believed to be Tibetans, which was transporting 300 tons of electrical machinery by mules and camels for the erection of a hydroelectric power plant, as reported in *Power*, July 21, 1925 issue, in the "Forbidden City," of Lhasa in Tibet. The machinery is said to have been destroyed.

The plant was manufactured by an English firm for lighting and other purposes and was to have been the first admitted into Lhasa. The notorious jealousy of foreign intrusion into the "Forbidden City" was manifested by a stipulation in the contract that the plant must be conveyed and the work superintended by Tibetans. Accordingly, it was intrusted to a young Tibetan named Ringang, who was educated in England and trained as an engineer.

Ringang, who was related to the Dalai Lama, ruler of Tibet, left England with the machinery about eight months ago. He is known to have completed the 400-mile journey from Kalimpong, Bengal, and was not heard of afterward. Agents sent from Calcutta and Bombay learned that disaster had befallen the party, which, it is reported, was met on approaching Lhasa by representatives of the new Tibetan government and murdered in a Himalayan Mountain pass 12,000 ft. high. All the machinery was destroyed and the wreckage thrown over a precipice.

Hughes Commission Recommends Uniting Water Control and Water Power Commissions

Department of Conservation to Be Under Governor's Control—Board to Be Composed of Conservation Commissioner, Commissioner or Deputy from Public Works Commission and Attorney-General

THE changes in the structure of the New York state government which are provided for in the report of the State Reorganization Commission, headed by Charles E. Hughes, was submitted to the legislature at its night session on March 1. The commission which has been at work for months preparing an elaborate plan for the reconstruction of the administrative departments in conformance with the amendment which received the approval of the voters at the election last year contains, the following recommendations, after a lengthy survey of the Water Control Commission and the Water Power Commission, regarding a merger of the two boards under the Conservation Department:

It is recommended that all of the functions of both the Water Control Commission and Water Power Commission be consolidated and vested under the control of a single commission, whose functions shall be definitely made a division of the Department of Conservation. It is believed that these functions are too important and far reaching to be vested in the discretion of a single individual, and, therefore, we recommend the creation of a new commission to administer all of these functions now exercised by the two commissions. Chiefly because of the volume of work and the amount of time which will be consumed by this new commission, we recommend that the Speaker of the Assembly and the President pro-tem of the Senate be not made members of the commission. The relatively great importance of engineering and technical considerations arising in matters before this commission make it essential that there be associated with it either the Commissioner of Public Works or an experienced engineering deputy to be assigned by the Commissioner of Public Works. We are opposed to any form of reorganization which would result in building up under this commission any separate engineering or technical force, it being felt that all of these features may best be cared for through appropriate correlation with the Department of Public Works. This is also in line with the statutory provisions defining the methods to be employed by the Federal Power Commission and with the actual experience of that commission. The chairman of the new commission should be the Conservation Commissioner, who should also be vested with power to appoint all of the subordinates thereof and to promulgate all rules and regulations governing the procedure of the commission. Because of the grave importance of the questions of policy which will present themselves, it is recommended that the Attorney General of the state be made ex-officio the third member of this commission.

In view of the importance of grants of waterpower rights, it is recommended that these grants be made subject to the approval of the Governor, and that, as in case of land grants, the signature of the Governor be required upon the issue of licenses.

Construction of Pit River No. 4 Plant

On August 1st of last year Pit River No. 3 plant of the Pacific Gas & Electric Co. was formally placed in service. This plant contains three 33,000-hp. units operating under a gross 307-ft. head. Work is now well under way on the No. 4 plant which is about ten miles farther down the river from plant No. 3. This new plant will contain three 40,000-hp. units operating under a 377-ft. head.

About three miles below plant No. 3 a diversion dam, 430 ft. long is being built that will raise the river to the tailwater elevation of this station. During construction of the dam the river will be diverted around it through a flume excavated in the hill side and will start about 500 ft. above the dam site and end about 900 ft. below. From above the diversion dam a tunnel 19 ft. in diameter and 23,782 ft. long will conduct the water to the hill side above plant No. 4. Near this point the tunnel connects with a concrete surge chamber cut into the side of the hill. The lower portal of the tunnel will connect to a manifold that branches to accommodate three steel-plate penstocks.

A bill granting the consent of Congress for the construction of a dam in the Des Moines River has been reported favorably. The dam is to create a pool for condensing water.

Muscle Shoals Again Being Discussed in the Senate

Alabama Public Service Commission Protests Government Operation—Senator La Follette Declares "Cheap Fertilizer" a Blind—Senator Norris' Point of Order Defeated

DISCUSSION on Muscle Shoals in the United States Senate is still continuing as this is written. Various amendments have been offered but not one of them has come to a vote. Any amendment whatsoever to the concurrent resolution is being opposed.

Senator Heflin of Alabama, who is in charge of the resolution on the floor, explains the opposition to amendment as follows: "The Muscle Shoals matter has been before the Senate frequently. We know that every measure which has come before this body on the subject has been killed by amendment. The language already used should stand. The time is very short. I hope we may pass the resolution without having to send it back to the House."

This led Senator Caraway of Arkansas to remark: "I cannot see why the Senator from Alabama should object to giving the committee the power to get the very best offer. The committee is not going out to do a foolish thing unless we tie its hands so it cannot do a wise thing."

Senator Robinson, the Democratic leader, was at a loss to understand the objection to amendments. He said: "The Senator from Alabama may imply that every senator who seeks to improve or perfect legislation is in some mysterious or secret manner trying to throttle or defeat the legislation, but I have called him repeatedly to state a reason that sounds like common sense, a reason that will appeal to this chamber. Why should the Senate abdicate its legislative power and refuse to adopt an amendment which it believes ought to be placed upon the resolution?"

The debate revealed that there is strong opposition to any lease of the power properties, particularly under conditions which might result in large profits to any private interest. Were the Ford offer to be renewed, it is apparent that it would not be supported by more than a corporal's guard. More senators apparently are convinced that fertilizers cannot be manufactured at Muscle Shoals at a cost that will permit of competition with the products of commercial plants. There is strong opposition to any subsidy, either direct or indirect. Many senators are coming rather reluctantly to the belief that the only asset at Muscle Shoals is the power. While only a few think the government should undertake to distribute the power, it is evident that there will be very strong opposition to the use of the power under any long lease. Opinion in the upper chamber seems inclined toward the distribution of the power as the most equitable use that could be made of it until some way can be found to use it to advantage in the manufacture of fertilizer. On the other hand, it is known that several very influential senators think the power could be used to greatest advantage, during the time experiments in nitrogen fixation are in progress in the manufacture of chemicals.

Senator Norris' effort to dispose of the resolution by a point of order was lost 55 to 15 when he appealed from the decision of the chair. He contended that the joint resolution contains legislation which may not be carried on a measure which is not to be referred to the President. Vice-president Dawes, however, accepted the view that the resolution only provides for the establishment of certain facts which are to be reported to Congress. Any of the recommendations of the committee which are put into effect will have to take the form of a regular bill which must be signed by the President, or passed over his veto, before it can become a law.

Senator Smith of South Carolina made the point that Muscle Shoals is not a power project and that the $150,000,000 it cost would never have been voted for a power project. It was built, he said, in an effort to make the country independent in the matter of nitrogen. He opposed disposing of it to any private corporation. At another point in his remarks Senator Smith declared it would open the door to scandal were a committee in Congress "to go out and traffic with corporations, trusts and combines in order to turn over to them a property worth hundreds of millions of dollars." Congress, he pointed out, must pass ultimately on bids which are made for the properties. It would be much better, he said, to authorize an executive agency to do the negotiating.

Senator Caraway of Arkansas presented two amendments, one to add after the word "lease" the words "or leases" and another providing that surplus power "be equitably distributed among the communities and states to which it may be properly transported."

Senator La Follette of Wisconsin declared that "cheap fertilizer for the American farmer," was the blind behind which politicians and power interests conceal their opposition to government operation of Muscle Shoals. In years to come, he said, Muscle Shoals must be primarily a hydro-electric power project, not a fertilizer one. He accused the power and fertilizer interests of combining to bring about private operation and accused the administration of inconsistency in supporting the Boulder Dam bill, involving public operation on the Colorado while opposing public operation on the Tennessee. Congress, the Senator said, was "besought to authorize one more whirl in the whirligig of commissions and committees and to confuse and tire out public resistance so that this hundred-and-fifty-million-dollar investment of the people may be leased into private hands."

The first deficiency bill about to become a law carries $2,000,000 for the purchase of transformers for use at Muscle Shoals and for the completion of the work on the dam. At the present time transformers belonging to the Alabama Power Co. are being used. That equipment, however, is intended for another development.

General Taylor pointed out that it will be to the advantage of the government to own the transformers. It then will be possible to get four mills for the power, he believes, instead of two mills at present, provided authority is given to make a contract for six months.

Smith's Sound, New Zealand, Development Gets License

The New Zealand Sounds Nitrates Syndicate, which is composed of New Zealand business men, has been granted a sixty-years' license by the New Zealand government to generate at Smith's Sound 300,000 continuous horse-power, 50,000 of which is to be developed within seven years, while the construction of works to generate the balance must be begun within ten years. The government retains the right to resume possession with compensation at the end of thirty years. The power produced is to be used for electrochemical, metallurgical and other purposes. The rental payable to the government is one shilling per annum per kilowatt. Although the price to consumers for lighting purposes is restricted to a penny a unit this is merely formal as the territory is uninhabited.

University Presidents Back Research in Pure Science

The National Academy of Sciences announced on Feb. 28 that its effort to start a fund to encourage scientific research throughout the country had been endorsed by thirty university presidents, who "find that many factors are tending to stifle the growth of fundamental scientific investigation."

Lack of opportunity for research rather than a shortage of skilled investigators was held to be the chief obstacle to development.

President James R. Angell of Yale said that "university scientists frequently labor under heavy handicaps due to inability to secure needed apparatus and skilled assistants. The burden of teaching often saps energy and breaks up the necessary continuity of effort."

President John Grier Hibben of Princeton considered that "pure science research has had little encouragement in our country, and the time has come to provide every facility for its progressive development."

In the opinion of President David Kinley of the University of Illinois, "research in the fundamentals is necessary if applied science is to flourish. The water fails when the spring dries up."

Secretary Hoover has been apointed Chairman of an Academy board charged with advancing the project.

It has recently been announced that the department of administrative engineering in the Sheffield Scientific School at Yale University is changing its name to the department of industrial engineering.

Conowingo Financing Plans Arranged Satisfactorily

The Philadelphia Electric Co. is preparing to begin construction of its $52,200,000 hydro-electric plant on the Susquehanna River below Conowingo, Md., as a result of the Federal Power Commission's approval on Feb. 27 of the financing of the project.

To guard against any contingency under which the Philadelphia Electric Co. might lose control of the Conowingo project, the Federal Power Commission has required that the entire common stock issue be held in the treasury of that company, free from any form of incumbrance that would divest that company from majority control.

The order of the Federal Power Commission as to the security issues also requires that the preferred stock is never to exceed one-third of the par value of the bonds. This provision is held to be necessary to leave an adequate margin of earnings.

The redemption price of the preferred stock was ordered reduced to $28. The request for the issuance of a small block of non-par common stock was denied.

Sesqui-Centennial Gets Federal and Local Funds

The Federal contribution to Philadelphia's celebration of 150 years of national independence was limited by Congress to $2,186,500.

Of that sum, $1,186,500 will be expended by the Federal Commission, composed of Secretaries Kellogg and Hoover, for exhibits, and $1,000,000 by the Exposition Commission for the erection of buildings.

Congress imposes the further restriction that in the event of any fiscal deficit the federal government will assume no share.

The amount falls far short of Mayor Kendrick's estimate of a worth-while Federal contribution. It is less than half of the $5,000,000 Congress appropriated for the Chicago World's Fair in 1893 and the St. Louis Louisiana Purchase Exposition in 1904, when construction costs were far below those of the present.

In speaking of the appropriation Mayor Kendrick said: "A little less than I expected; but nevertheless, very gratifying."

The Philadelphia Council on Feb. 18 passed an ordinance creating a $1,000,000 emergency loan for the use of the Sesqui-Centennial International Exposition. With that additional sum made available, the city will have provided $9,700,000 in all for the celebration, of which $3,000,000 was raised by popular subscription.

A. L. Austin, controller and business manager of the Sesqui Association submitted an estimate to the Council before the ordinance was approved, of $14,060,000 as the total outlay, which will be required to make the celebration a success. Although Congress has voted $2,186,500 for federal participation and the state of Pennsylvania has appropriated $750,000 toward the Sesqui, the total amount which will be available falls short of the controller's estimate.

Australia Invites Bids on Power Plant Equipment

Specifications have been issued by the State Electricity Commission of Victoria, Melbourne, Australia, inviting bids on synchronous condensers and accessory plant. The closing date is May 24, 1926. Copies of the specifications are on sale in the New York district office, 734 Customhouse, and the Chicago district office, 76 West Monroe Street, of the Bureau of Foreign and Domestic Commerce.—*Commerce Reports.*

Colorado River Development Bill Amended

The amended Swing-Johnson bill for the Boulder Canyon dam project and development of the Colorado River was introduced on Feb. 27 in both branches of Congress.

The principal change in the bill is that the government would raise $125,000,000 by a bond issue instead of making a straight appropriation. The comprehensive plan for flood control, irrigation and power remains substantially the same.

The new bill provides, as did the one introduced earlier in the session, for the ratification of the Colorado River compact by any six of the seven states affected. Representative Hayden, Democrat, Arizona, has announced he will oppose the measure on the ground that it discriminates against Arizona, which has refused to ratify the agreement.

Representative Swing said the bill probably would be amended further in minor particulars to include suggestions by the Department of the Interior.

Falls of the Cumberland May Be Used for Power

By releasing ample water to preserve the full beauty of the falls of the Cumberland during the day and by storing the entire flow of the river at night, a plan has been worked out which is expected to permit the development of power available at that point on the Cumberland River.

Under the original plan the falls would have been dry during the period of low water. This proposal resulted in an effort to arouse nation-wide objection on the ground that the power development would mar the scenic beauty of the waterfall. The effort was sufficiently successful as to threaten the development.

Major Harold C. Fiske, representing the Federal Power Commission and the Corps of Engineers, has conferred with the Governor of Kentucky in regard to the new plan and apparently it meets with general approval.

The proposed reservoir will provide for the regulation of the water passing over the falls so that its beauty will be enhanced greatly during the low-water period.

In view of these developments it is expected that the Federal Power Commission will be able to grant the application of the Cumberland Hydro-Electric Co. for the development. The requirement as to the release of water for the falls during the day will be made a condition of the license.

Ice Gorge Puts Power Plants Out of Commission

The main power plant at Oil City, Pa., has been out of commission for several days, due to the unprecedented flood and ice gorge at Franklin, and Oil City, Pa., in the Allegheny River. The auxiliary plant at Franklin has been trying to maintain partial service but has been unable to meet the needs of the two cities, which have both been in partial darkness due to the flooding of boiler rooms at power plants.

The ice gorge which has been reported as being five feet above the usual flood level and estimated as fifty miles long is still frozen in tight as this is written. At Oil City the situation is worse than at Franklin as there is an eighteen-mile ice gorge forty miles above the city which is likely to break at any time.

Major E. L. Daley, U. S. district engineer at Pittsburgh, told the mayors of the two towns that it would be useless to dynamite the ice.

One ton of "thermite" a chemical invented by Dr. Howard Barnes of Magill University, Montreal, is to be placed in the 18-mile gorge in the hope that its properties, generating a heat of 5,000 deg. F., may at once become evident and loosen the gorge. This chemical has already been used, according to Dr. Barnes, in moving the ice in the St. Lawrence River.

Five-Ton Fly Wheel Bursts in Webster, Mass.

The explosion of a 20-ft., 5-ton flywheel in the power plant of the South Village Mills of the American Woolen Co. at Webster, Mass., on Feb. 24, wrecked the power house and endangered many lives. It is the general understanding in Webster that heavy loss of life was averted by the bravery of the engineer and the assistant master mechanic..

When approached by a *Power* correspondent, officials of the American Woolen Company refused any information augmenting or correcting the early reports in the daily press. According to these unverified reports, the plant contained seven engine-driven alternating-current generators supplying power to the mill. For some reason not made clear, one of the engines started to race, with the resulting explosion of the flywheel.

Pieces flew in all directions, wrecking the engine room and endangering the lives of mill employees, pedestrians and children playing in the vicinity. One piece, it was stated, severed the steam main. Charles Blais, assistant master mechanic, dazed and bleeding from being hurled through a window, is said to have crawled into the boiler room and shut off the oil burners on the eleven boilers.

Another hero, according to the reports, was John Harbot, the engineer, and the oldest employee of the American Woolen Co. in the town. Harbot cut off the steam supply to the runaway engine. These two men were assisted by Victor Cassavant, boss piper. Among those who had narrow escapes was Morris Galvin, fireman at the plant.

Regional A.S.M.E. Meeting Plans Maturing

The New England Regional meeting of the A.S.M.E. which will be held in Providence, R. I., May 3-6, will be under the auspices of the New England and Providence Sections of the society. "Industrial Education" will be the subject of the opening session on Monday, May 3; "Industrial Power" will be discussed at the Tuesday morning session; "Central Station Problems" will be considered on Wednesday morning. The program will be issued shortly.

Society Affairs

The Carolinas Section of the A.S.M.E., Raleigh Branch, will hold a meeting on March 10 at which A. G. Christie of Johns Hopkins University will speak on "Pulverized Fuel."

The Metropolitan Section of the A.S.M.E., will hold a meeting at 29 West 39th St., New York City, on March 24. "Opportunities for Engineers in Industry," will be the topic for the evening.

The Detroit Section of the A.S.M.E. with the A.I.E.E. will hold a meeting on March 16 at 2000 Second Blvd., Detroit, at which W. L. R. Emmet of the General Electric Co. will speak on "The Mercury Vapor Process of Driving Turbines."

The Connecticut Section of the A.I.E.E. will hold its March 9 meeting at the Hartford Electric Light Co.'s auditorium, 266 Pearl St., Hartford, Conn. Samuel Ferguson, president of the Hartford Electric Light Co., will speak on "The New England Power Pool."

The American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. C. L. Warwick, secretary, is holding some joint committee meetings in conjunction with a three-day group meeting at Providence Biltmore, Providence, R. I., March 17-19. Two sessions on corrosion will be held.

The Lehigh Valley Section of the A.I.E.E. will hold its March 26 meeting at Wilkes-Barre, Pa. Papers on "Automatic Control of Centrifugal Pumps," by Otto Haentjens of Barrett, Haentjens & Co., and "Wallenpaupeck Hydro-Electric Development of the Pennsylvania Power & Light Co.," by N. G. Reinecker will be the attractions.

The American Oil Burners' Association, Leon D. Becker, Secretary, 350 Madison Ave., New York City, will hold its convention and exposition this year at the Book Cadillac Hotel, Detroit, Mich., April 6-8. A program of addresses and papers from outstanding men and authorities on oil burning problems will be given during the three days of the convention.

The Plant Engineers' Club of Boston will visit the new Edgar station, formerly called the Weymouth station, of the Edison Electric Illuminating Co. of Boston on March 10 at 2:30 p.m. The visit will be followed by an informal dinner at the Boston City Club, after which there will be a discussion by the members on "Purchased Power vs. Plant Power." This meeting was postponed from Feb. 10 on account of inclement weather.

Coming Conventions

American Boiler Manufacturers Association. D. W. Glanzer, 840 Rockefeller Bldg., Cleveland, Ohio. Annual convention at Homestead, Hot Springs, Va., June 1-2.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Annual convention at White Sulphur Springs, W. Va., June 21-25.

American Society for Testing Materials. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Convention at Haddon Hall, Atlantic City, N. J., June 21-25.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Spring convention at San Francisco, Calif., June 28-30.

American Water Works Association. W. M. Niesley, Assistant to Sec., 170 Broadway, New York City. Annual convention at Hotel Statler, Buffalo, N. Y., June 7-12.

American Welding Society. M. M. Kelly, 29 West 39th St., New York City. Annual convention at 29 West 39th St., New York City, April 21-23.

Association of Iron & Steel Electrical Engineers. John F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Exposition and convention at Hotel Sherman, Chicago, Ill., June 7-10.

Heating & Ventilating Exposition. E. P. Frenz, Hotel McAlpin, New York City. Exposition at new Madison Square Garden, New York City, Mar. 17-23.

Master Boiler Makers Association. Harry D. Vought, 26 Cortlandt St., New York City. Annual convention at the Statler Hotel, Buffalo, N. Y., May 25-26.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. Convention at Atlantic City, begins Sept. 14. Erroneously announced as Sept. 6-11. Annual conventions and exhibitions of state association are scheduled as follows: **Indiana State Association,** F. L. Clifford, 653 South Union St., Kokomo, Ind., Convention at Lafayette, Ind., May 10-15; **New England States Association.** Freeman L. Tyler, 32 Briggs St., Taunton, Mass. Convention at New Bedford, Mass., June 16-19; **Ohio State Association,** T. S. Garrett, 2622 E. Second St., Dayton, Ohio, Convention at Newark, Ohio, June 17-19; **Connecticut State Association,** George F. Klopfer, 30 East Pearl St., New Haven, Conn., Convention at Norwich, Conn., June 25-26; **Minnesota State Association,** C. A. Nelson, 800 22nd Ave., N. E. Minneapolis, Minn. Convention at Rochester, Minn., Aug. 4-6; **New Jersey State Association,** S. G. Dalrymple, 111 Hutton St., Jersey City, Convention at Atlantic City, Sept. 12; **Pennsylvania State Association,** Frank J. McCarron, 3647 North 11th St., Philadelphia, Convention at Philadelphia, Sept. 12-13.

National Board of Boiler and Pressure Vessel Inspectors. C. O. Myers, 14 Commercial National Bank Bldg., Columbus, Ohio. National Board meeting at Chicago, Ill., May 3-5.

National District Heating Association. D. L. Gaskill, Greenville, Ohio. Convention at Niagara Hotel, Niagara Falls, June 1-4.

National Electric Light Association. A. Jackson Marshall, 29 West 39th St., New York City. Forty-ninth convention and manufacturers' exhibition, at Atlantic City, Young's Million Dollar Pier, May 17-21.

Power Show. International Textile Exposition—James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show will be Department "D" of the International Textile Exposition, and will be under the auspices of the New England Association of Commercial Engineers, and held at the Mechanics Bldg., Boston, Mass., April 12-17.

Sesquicentennial International Exposition. Capt. Asher C. Baker, director in chief. Independence Square, Philadelphia. Exposition to be held in Philadelphia, Pa., from June 1 to Dec. 1.

Business Notes

The Petroleum Heat and Power Co., formerly located at 1775 Broadway, is now located at 511 Fifth Ave., New York City.

The Diamond Specialty Corp., Detroit, Mich., announces the appointment of J. E. Heeter as manager of the Philadelphia office.

The Chicago Fuse Manufacturing Co., Laflin and 15th St., Chicago, Ill., announces that A. E. Tregenza has just been made vice-president of the company in charge of sales.

The Midwest Piping & Supply Co., 1450 South Second St., St. Louis, Mo., announces that C. S. Simon has been placed in charge of the office of the company at 805 Mayo Bldg., Tulsa, Okla.

The Bartlett Hayward Co., 350 Madison Ave., New York City, has announced the appointment of F. W. Thomas as representative for the sale of Fast's flexible couplings in the New York City territory.

The Homestead Valve Mfg. Co., Homestead, Pa., announces that the Smith Separator, Chestnut & Smith Corp. Bldg., Tulsa, Okla., has been appointed agent for the company in the states of Oklahoma and northern Texas.

The Lee B. Mettler Co., 406 South Main St., Los Angeles, Calif., announces the appointment of The Daly Co., 1425 Sixteenth St., Denver, Colo., as its representative in the Rocky Mountain district which includes Colorado, Wyoming and New Mexico.

The Foote Bros. Gear & Machine Co., 215 N. Curtis St., Chicago, Ill., announces that H. H. Snell, formerly with the Chas. Bond Co., has been appointed district representative for eastern Pennsylvania, Delaware, Maryland and the southern half of New Jersey.

The Worthington Pump & Machinery Corp., 115 Broadway, New York City, has recently received an order for four 22-in. x 36-in. twin tandem double-acting gas engines and for three 22-in. x 36-in. single tandem double-acting gas engines from the United Fuel Gas Co., Charleston, W. Va. All seven engines are to be arranged for gas compressor drive.

Toch Brothers and the **Standard Varnish Works of New York** have recently been merged, according to an announcement made by the new firm. Henry W. Toch, president of Toch Brothers, is chairman of the Standard Varnish Works and Maximilian Toch, vice-president, is in charge of manufacture. Toch Brothers recently celebrated its 76th anniversary. The Standard Varnish Works is located in Staten Island; Toch Brothers occupies 22 buildings on Long Island. The sales organizations of the two companies will continue to function separately although the New York offices of the two companies will be both located at 443 Fourth Ave., New York City.

The American Hoist & Derrick Co., St. Paul, Minn., has recently opened another branch office at 1943 Railway Exchange Bldg., St. Louis, Mo., with Ward B. Maurer in charge.

The Raymond Bros. Impact Pulverizer Co. office has been removed from 43 Broad St. to 342 Madison Ave., New York City. S. B. Kanowitz, eastern manager will be located at this new address.

The Graybar Electric Co., 100 E. 42d St., New York City, formerly the supply department of the Western Electric Co., announces the following changes: George E. Cullinan has been elected vice-president in charge of sales and a director of the company; Leo M. Dunn has been promoted to the vice-presidency and will have charge of merchandising and accounting; R. F. Copes has been appointed sales manager of the Norfolk, Va., distributing house; F. G. Caldwell has been appointed manager of the Houston, Texas, distributing house; W. B. DeForest has been transferred from Kansas City to New York City as sales manager of the company; C. V. Robinson has been appointed credit manager at Richmond, Va., succeeding F. S. de Gruchy, who has been transferred to the credit department of the New York City office, 401 Hudson St.; J. F. Davis, formerly sales manager at New York, has been transferred to the general staff of the company at 100 East 42d St., New York City. The Western district which has been transferred from St. Louis to Kansas City will have H. N. Godell as district manager.

The Bridgeport Brass Co., Bridgeport, Conn., announces that Herman Steinkraus has recently assumed the representation of the company's products in the Cleveland territory, with offices at 2017 Superior Viaduct, Cleveland, Ohio.

The American Engineering Co., Armingo and Cumberland Sts., Philadelphia, Pa., recently delivered a stoker for firing a boiler of 12,870 sq.ft. of heating surface, for the power house of Dodge Brothers, Inc. The stoker was designed, built, shipped from Philadelphia to Detroit, installed and the acceptance tests run six weeks after the signing of the order. This was the first of four stokers to be installed. The company also reports the sale of four Taylor underfeed stokers to the United Illuminating Co. of New Haven, to be installed under four boilers of 6,500 sq.ft. heating surface each.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; *mine run* except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	Mar. 1, 1926
Pool 1	New York	$2.75@$3.10
Smokeless	Boston	1.97
Clearfield	Boston	1.90@ 2.25
Somerset	Boston	2.00@ 2.35
Kanawha	Columbus	1.40@ 1.7
Hocking	Columbus	1.35@ 1.67
Pittsburgh	Pittsburgh	2.00@ 2. 0
Pittsburgh gas slack	Pittsburgh	1.15@ 1.25
Franklin, Ill.	Chicago	2.35@ 2.50
Central, Ill.	Chicago	2.00@ 2.25
Ind. 4th Vein	Chicago	2.25@ 2.35
West Ky.	Louisville	1.25@ 1.50
S. E. Ky.	Louisville	1.35@ 1.50
Big Seam	Birmingham	1.50@ 2.00
Anthracite, Gross Tons		
Buckwheat No. 1.	New York	3.00@ 5.00
Buckwheat No. 1.	Philadelphia	3.00@ 3.50
Birdseye	New York	2.00

FUEL OIL

New York—Mar. 4, light oil, tank-car lots; 28@34 deg. Baumé, 5½c. per gal.; 36@40 deg., 6c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Feb. 23, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.95 per bbl; 26@28 deg., $2.00 per bbl.; 28@30 deg., $2.05 per bbl.; 30@32 deg., $2.10 per bbl.; 32@36 deg., gas oil, 5.6c per gal.; 38@40 deg., 6c. per gal.

Pittsburgh—Feb. 25, f.o.b. local refinery; 30@34 deg., fuel oil, 6c. per gal.; 36@40 deg., fuel oil, 6½c. per gal.

Dallas—Feb. 19, f.o.b. local refinery; 26@30 deg., $1.65 per bbl.

Philadelphia—Feb. 26, 27@30 deg., $2.31@$2.37 per bbl.; 18@22 deg., $1.75@$1.81; 13@19 deg., $1.68@$1.74 per bbl.

Cincinnati—Mar. 1, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6¾c. per gal.; 30@32 deg., 7c. per gal.

Chicago—Feb. 23, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.30 per bbl.; 26@30 deg., $1.35; 30@32 deg., $1.55@$1.60.

New Plant Construction

Calif., Alameda—Bd. of Education, W. G. Paden, Secy., will soon receive bids for shop additions and extension to high school and boiler house, including equipment, etc.

Calif., Beaumont — Beaumont Irrigation Dist., plans an election to vote $25,000 bonds to finance drilling of wells, purchase of pumps and constructing pipe line. C. R. Sumner, H. W. Hellman Bldg., Los Angeles, is engineer.

Calif., Los Angeles—Los Angeles Housing Corp., Black Bldg., had preliminary plans prepared for the construction of a 13 story office building including steam heating system and 4 elevators on Main St. Estimated cost $750,000. E. Van Den Hoven, Black Bldg., is architect.

Calif., Los Angeles—J. W. Sappington, 1972 South Los Angeles St., is having preliminary plans prepared for the construction of a 13 story apartment including steam heating system and elevators. Estimated cost $1,250,000. R. Nicolais, 686½ South Vermont Ave., is architect.

Calif., Salinas—Salinas Valley Ice Co., F. S. Meyers, Genl, Mgr., had plans prepared for the construction of addition to ice plant, 50 ton daily capacity. Estimated cost $40,000.

Fla., Clearwater—Pinellos Power Co. has purchased a site and plans the construction of a power plant on Vine St. Estimated cost $50,000.

Fla., Daytona Beach—J. P. Stoltz, c/o C. L. Allen, awarded contract for the construction of a 15 story "Fleetwood" hotel on Fairyland Point to Bucholz Construction Co., Asheville, N. C. Estimated cost $2,000,000.

Fla., Fort Myers—Fort Myers Community Hotel Corp., c/o C. W. Russell, awarded contract for the construction of a 10 story hotel at Anderson Ave. and McGregor Blvd., to Day & Zimmerman, Inc., Sixteenth and Walnut Sts., Philadelphia, Pa. Estimated cost $650,000.

Fla., Tampa—Permanent Improvements, Inc., D. S. Conoley, Pres., plans the construction of a 10 story office building at Lafayette and Grand Central Aves. Estimated cost $1,000,000. B. C. Bonfoey, 12 Petteway Bldg., is architect.

Ill., Chicago — Alpine Hospital, A. N. Moore, Pres., 6646 Stony Island Ave., will receive bids about March 15 for the construction of a 6 story hospital on Ellis Ave. Estimated cost $1,000,000. Hall, Lawrence, Rippel & Ratcliffe, 123 West Madison St., are architects.

Ill., Chicago—Graham, Anderson, Probst & White, 80 East Jackson Blvd., Archts., will receive bids about March 20 for the construction of a 12 story office building at Canal and Clinton Sts., for Chicago Machinery Mart, 14 East Jackson Blvd. Estimated cost $3,200,000.

Ill., Chicago—Guske & Foster, 750 North Michigan Ave., Archts., are receiving bids for the construction of an 18 story apartment at 241 Pearson St. for P. M. Gordon, 316 Pine Grove Ave. Estimated cost $2,400,000.

Ill., Chicago—Frederick T. Hoyt & Associates, 160 North La Salle St., awarded contract for the construction of a 15 story apartment at 1209-1217 Astor St. to Lundoff-Bicknell Co., Keith Bldg., Cleveland, O. Estimated cost $1,500,000.

Ill., Chicago—J. Hunt & Associates, 30 North Michigan Ave., is having plans prepared for the construction of a 16 story apartment at Lake Shore Drive and Pearson St. Estimated cost $5,000,000.

Ill., Chicago—S. Isenstein & A. Smith, 2726 West Roosevelt Road, are having plans prepared for the construction of a 6 story hotel at Racine and Leland Aves. Estimated cost $650,000. Duin & Eisenberg, 14 West Washington St., are architects.

Ill., Chicago—Rissman & Hirschfeld, 64 West Randolph St., Archts., are receiving bids for the construction of a 14 story hotel at Walton Place and North Michigan Ave. for Davis Hotel Corp., 831 Wilson Ave. Estimated cost $3,000,000.

Ill., Chicago—Sanitary Dist., H. E. Wallace, Clk., Room 700, 910 South Michigan Ave., will receive bids until March 18 for furnishing and installing four 500 hp. water tube boilers, complete with automatic traveling grate stokers and miscellaneous equipment, four 500 hp. water tube boilers complete with mechanical oil burners and miscellaneous equipment at North Side Sewage Treatment Works.

Ill., Decatur—City awarded contract for the installation of two 625 kw. steam turbine generators with exciters, 2 panel switchboard and two 1250 ft. surface condensers in power plant to Allis-Chalmers Co., West Allis St., Milwaukee, Wis. Estimated cost $34,030, $2,655 and $13,475, respectively.

Ill., Highland—City is having preliminary plans prepared for improvements to light plant, including new engine generating unit, etc. Estimated cost $30,000. W. A. Fuller Co., 1917 Railway Exchange Bldg., St. Louis, Mo., is engineer.

Ill., Warsaw—City, E. Ziegler, Clk., will receive bids until March 31 for the construction of a 250 g.p.m. rapid sand filtration plant, including pumps, motors, 100,000 gal. tank on tower, etc. Estimated cost $300,000. E. Flad & Co., 1312 Chemical Bldg., St. Louis, Mo., are engineers. Former bids rejected.

Ill., Wilsonville—City is having preliminary surveys made for the construction of waterworks and distribution systems including pumping equipment, tank on tower, etc. Estimated cost $50,000. W. A. Fuller Co., 1917 Railway Exchange Bldg., St. Louis, Mo., is engineer.

Ind., Indianapolis—Bd. of Trustees of Indiana State Blind School, is having preliminary plans prepared for the construction of a power plant complete with equipment. Estimated cost $150,000.

Ia., Des Moines—J. A. Raymaker, Consulting Engr., c/o Woods Bros. Thresher Co., owner, will receive bids until March 15 for the construction of 2 manufacturing buildings including a 40x60 ft. power plant, etc.

Ia., Iowa City—State University, W. H. Gemmill, Secy., State House, Des Moines, will soon award contract for the construction of a heating plant here. Estimated cost $700,000.

Kan., Eldorado—City plans an election March 16 to vote $450,000 bonds for improvements to waterworks, including pumps, etc., also a dam across Willow Creek. Black & Veatch, 701 Mutual Bldg., Kansas City, Mo., are engineers.

La., Shreveport—Kansas City Southern R'y., Kansas City, Mo., plans the installation of a water pumping station and pipe. Estimated cost $27,000. A. W. Reece is chief engineer. Work will be done by owner's forces.

Miss., Cleveland—Mississippi Delta State Teachers College, J. W. Broom, Pres., is having preliminary plans prepared for the construction of a dormitory and academic building including central heating plant. Total estimated cost $360,000.

Miss., Long Beach—J. J. Bailey, Mayor and Bd. of Alderman, will receive bids until March 23 for improvements to waterworks, including pump house, two 250 g.p.m. fire pumps, either motor driven, centrifugal or oil engine power pumps. Swanson-McGraw, Inc., 426 Balter Bldg., New Orleans, La., are engineers.

Mo., St. Louis—Bd. of Public Service, City Hall, will receive bids in April for the construction of a service building, including power plant, transformers, 200 ft., etc. Total estimated cost $1,000,000. Study & Farrar, Arcade Bldg., are architects.

Mo., St. Louis—Polar Wave Ice & Fuel Co., 3638 Olive St., has purchased a site and plans the construction of an ice plant and distribution station at Ninth and Victor Sts. Estimated cost $250,000.

Mo., St. Louis—St. Louis Maternity Hospital, 4518 Washington Blvd., awarded contract for the construction of an 8 story hospital on Kings Highway to John Hill Construction Co., Syndicate Bldg.

Mo., St. Louis—Union Electric Light & Power Co., L. H. Egan, Pres., Twelfth and Locust Sts., plans to expend $11,000,000 for construction work, including additions to Kahokis and Ashley power plants, substations and line extensions.

N. J., Atlantic City—Childs Co., 200 5th Ave., New York, N. Y., is having plans prepared for the construction of an 18 story hotel and restaurant at Boardwalk and Carolina Ave. here. Estimated cost $2,500,000. George B. Post & Sons, 101 Park Ave., New York, N. Y., are architects.

N. J., New Brunswick—St. Peter's Hospital, J. H. Conger, V. Pres., had plans prepared for the construction of a 5 story hospital on Easton Ave. Estimated cost $800,000. McGinnis & Walsh, Boston, Mass., are architects.

N. J., Paulsboro—Borough Council plans the construction of two new pumping stations, etc. Estimated cost $150,000. Engineer not selected.

N. Y., Brooklyn—H. E. Witteman, 6908 5th Ave., plans the construction of a 14 story office, theatre and stores building at Flatbush Ave. Extension and DeKalb Ave. Estimated cost $12,000,000. Work will be done by separate contracts under the owner's supervision. Architect not selected.

N. Y., Buffalo—H. J. Cook, et al., 408 Pearl St., is having plans prepared for the construction of a 12 story apartment. Estimated cost $1,225,000.

N. Y., New York—W. F. Chatlos, Broad St., Stratford, Conn., plans the construction of a 27 story office building at Lexington Ave. and 51st St., here. J. W. Northrop, 211 State St., Bridgeport, Conn., is architect.

N. Y., New York—L. Gerbino, c/o Schwartz & Gross, 347 5th Ave., Archts., is having plans prepared for the construction of a 22 story hotel at West End Ave. and 92nd St. Estimated cost $1,000,000.

N. Y., New York—Milnate Realty Co., c/o H. I. Feldman, 516 5th Ave., Archt. and Engr., will build a hotel on West 48th St. by day labor. Estimated cost $1,250,000.

N. Y., New York—M. Natanson, 522 5th Ave., awarded contract for the construction of a 22 story office building at Broadway and 57th St. to G. R. Davis, 30 East 42nd St. Estimated cost $6,000,000.

N. Y., New York—New York Edison Co., East 15th St., is having plans prepared for the construction of a 7 story public service building at 14th St. and Avenue D. Estimated cost $1,200,000. T. E. Murray Inc., 55 Duane St. is architect and engineer. Also awarded contract for a distributing station at Boston Road and 172nd St. to Ken-Well Contracting Co., 45 East 17th St. Estimated cost $150,000.

N. C., Kinston—Caswell Training School, L. P. Tapp, Chn. of Executive Committee, will soon award contract for additions and improvements including pump house, reservoir, water system, two centrifugal pumps and one fire pump, 1,000 g.p.m. capacity each.

O., Cleveland — Charity Hospital, East 22nd St. and Central Ave., plans the construction of a 5 story nurses home, laboratory, etc., including steam heating system. Estimated cost $1,200,000. George S. Rider Co., Century Bldg., is architect.

Okla., Collinsville—City plans an election March 11 to vote $81,000 bonds for improvements to power plant, completing water purification plant and extensions to distribution system, including pumps, etc. Holway Engineering Co., 505 Wright Bldg., Tulsa, is engineer.

Okla., Kaw City—City is having preliminary plans prepared for extensions and improvements to pumping equipment, etc. Estimated cost $20,000. Grant, Fulton & Letton, 505 Bankers Life Bldg., Lincoln, are engineers.

Okla., Quinlan—H. E. Hobson & Associates, have been granted a franchise to construct an electric power plant and power line. Estimated cost $75,000. Private plans.

Pa., Pittsburgh—J. I. Simon, 520 5th Ave., plans the construction of an office building at 6th Ave. and Ross St. Estimated cost $1,000,000. Jardine, Hill & Murdock, 347 Madison Ave., New York, N. Y., are architects and engineers.

Tenn., Memphis—C. F. Farnsworth, First National Bank Bldg., had plans prepared for the construction of a 12 story office building at South Main and Union Aves. E. L. Harrison, Union & Pacific Bank Bldg., is architect.

Texas—Macomber & West, c/o J. West, 15 Exchange Place, Boston, Mass., are making surveys for the construction of a large dam and several smaller ones for power development on the Guadalupe River extending from New Braunfels, north and south, to San Antonio here. Estimated cost $2,000,000. Payne, Weber & Co., Boston, Mass., are financing the projects.

Texas—State Bd. of Water Engineers, Austin, is having preliminary surveys made for the construction of a large dam and several smaller ones for power development on the Colorado River. Estimated cost $2,000,000.

Tex., Breckenridge—Alexander & Dillham is having plans prepared for the construction of a 40-ton ice plant and ice pier. Estimated cost $60,000. Withers & Merrell, 104½ Oak St., Mineral Wells, are engineers.

Tex., Brownsville — Brownsville Ice & Cold Storage Co., is having preliminary plans prepared for the construction of a 45 ton ice and cold storage plant. Estimated cost $100,000. Private plans. Machinery will be electrically driven.

Tex., Cleburne—Gulf, Colorado & Santa Fe Ry. Co., 408 Union Depot Bldg., Galveston, is receiving bids for the construction of shop buildings, boiler house, etc., here. Estimated cost $300,000. F. Merritt, is chief engineer. W. J. Smith, is architect.

Tex., Floresville—City is receiving bids for improvements to waterworks including pumping equipment, pumps, engine, etc. Estimated cost $40,000. F. E. Hess, is engineer.

Tex., Ft. Worth—J. Jones, c/o Tarrant Co., Medical Bldg., plans the construction of a 22 story hotel and theatre building at West Seventh, West Sixth and Taylor Sts. Estimated cost $1,500,000. W. C. Hedrick, First National Bank Bldg., is architect. Engineer not selected.

Tex., Harlingen—Henderson & Webb, will soon receive bids for the construction of a cotton gin. Estimated cost $40,000. Private plans. Machinery, including oil engines, will be required.

Tex., Mount Pleasant—Texas Public Service Co., Marshall, plans the construction of a 50-ton ice plant here. Estimated cost $70,000. J. Carpenter, Woolworth Bldg., Marshall, is engineer.

Tex., Nacogdoches—City voted $50,000 bonds for improvements to waterworks including pumping equipment, etc. Engineer not selected. W. I. Baker, is mayor.

Tex., Paris—Southern Ice & Utilities Co., Central Bank Bldg., Dallas, is having plans prepared for the construction of a cold storage plant here. Estimated cost $35,000. Private plans.

Tex., Quanah—Quanah Light & Ice Co., subsidiary of the Southwestern Light & Power Co., plans improvements to plant to increase the capacity to 40 tons daily.

Tex., Sabine—Southern Gas & Power Corp., Fox Bldg., Philadelphia, Pa., has acquired the Sabine Utilities Co.'s plant and plans improvements, including new machinery, etc., here. Private plans.

Tex., San Antonio—Smith Bros. Development Co., Crockett, awarded contract for the construction of a 12 story hotel including circulating ice water system, 4 elevators, etc., at Villita and St. Mary Sts., to McKenzie Construction Co., Travis Bldg. Estimated cost $600,000.

Tex., San Antonio—"Texas Food Packers," recently organized, plans the construction of canning, preserving, dehydrating and cold storage plants at different points throughout the state. New equipment will be required. Address B. D. Chapin, c/o National Bank of Commerce Bldg.

Tex., Schulenburg—Texas Central Power Co., S. M. Udden, Mgr., Frost Bldg., San Antonio, has acquired the Local Light & Ice Co.'s plant and is having surveys made for improvement to same including new machinery, etc. here. Private plans.

Wis., Beloit—Beloit Water Gas & Electric Co., A. Dobson, Mgr., plans drilling a well, 2,000,000 gal. capacity, also the installation of a 1,000 g.p.m. pump. Estimated cost $25,000. Engineer not selected.

Wis., Clintonville—Clintonville Canning Co., R. Greb, Mgr., will build a cannery, including a power house by day labor. Estimated cost $70,000. Private plans. Owner is taking bids on power boilers, etc.

Wis., Dodgeville—Dodgeville Cheese Federation, F. G. Swoboda, Gen. Mgr., plans the construction of a refrigeration and cold storage plant. Estimated cost $40,000. Architect not selected.

Wis., Waukesha—White Rock Mineral Spring Co., 1702 White Rock Ave., wants prices and data on a 70-hp. air compressor.

Ont., Chatham — Water Commissioners, wants prices and data on the installation of gasoline driven, 3 stage centrifugal pumps to replace present steam pumps, C. H. Fuller, City Hall, is engineer.

Que., Donacona—Donacona Paper Co. had plans prepared for the construction of a water power development, 2 units, 4,500 hp. capacity. Estimated cost $500,000. J. A. Beauchemin, is engineer.

Ont., Hamilton—City Council, wants prices and data on the installation of gasoline driven equipment to replace present steam driven pumps for waterworks. W. McFaul, City Hall, is engineer.

Ont., New Liskeard—Town, J. I. Dixon, Clk., plans the installation of two electrically operated sewage pumps in connection with sewage disposal works. Estimated cost $5,000.

Ont., Toronto—Township of Scarborough, will soon receive bids for the installation of a 1,000 gal., 3 stage centrifugal pump with 100 hp. electric motor. Estimated cost $7,500. R. Harrison, 1361 Kingston Road, is engineer.

Ont., Walkerville—Essex Border Utilities Commission, Murray Bldg., Windsor, plans the construction of a 3 story hospital including steam heating and ventilation systems, elevators, etc., here. Estimated cost $500,000. Pennington & Boyde, Bartlett Bldg., Windsor, and Stevens & Lee, 62 Charles St. E., Toronto, are architects.

Ont., Windsor—Waterworks Commission, plans extensions to pumping station including installation of a steam driven emergency pump. Estimated cost $25,000. M. E. Brian, City Hall, is engineer.

Ont., Windsor—Windsor Hydro Electric Railways, is having plans prepared for extensions to power facilities, etc. Estimated cost $1,000,000. Mr. Fairley, c/o owner, is engineer.

Que., Montreal—Silberman Herman Co. Ltd., 855 St. Laurence Blvd., is in the market for refrigeration machinery and equipment.

Australia, Melbourne—Victorian Government Railways, will receive bids until May 24 for two synchronous condensers and accessory plant.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Prices are higher than a month ago in fire protection hose and babbitt metal. The former rose 3c. per ft. and highest grade babbitt, 3½c. per lb., during the month. Structural rivets are off about 10c. per 100 lb. at mill, while boiler rivets remain firm and unchanged. Armored cable, two conduit, No. 14 solid, dropped 50c. per M ft. since February; three conduit is down $2. Rubber-covered copper wire is lower; linseed oil shows marked downward tendency.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

Fire Protection		50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket		(net) 74c. per ft.
Common, 2½-in., cotton-rubber lined	80c. per ft. list less	40%
Air—Best grade		
¾-in., per ft.	3-ply $0.37½	4 ply $0.46⅞
Steam—Discounts from List		
First grade 30–10%	Second grade 40%	Third grade 40–10%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade 50% Second grade 50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40–5%
Heavy	30–10%

RAWHIDE LACING For cut, best grade, 50%, 2nd grade, 60%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 50%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$1.05
Asbestos for high-pressure steam, ⅛ in.	1.85
Duck and rubber for piston packing	1.05
Flax, regular	1.15
Flax, waterproofed	1.70
Compressed asbestos sheet	.95
Wire insertion asbestos sheet	1.40
Rubber sheet	.60
Rubber sheet, wire insertion	.85
Rubber sheet, duck insertion	.65
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72½%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@ $2.70 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	15.00@22.00	19.00	20.00
Colored	10.00@15.50	10.00	17.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., for washed, white wipers, as follows:

Chicago	$0.16
New York	.18
Cleveland (per thousand)	36.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.84½	$1.02	$0.88

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b. New York:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	$15.25	$16.25	$16.75	$17.75
White	15.25	16.25	15.25	16.25

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Rivets, ½x1-in. and longer, 19c. per lb., less 50% at New York warehouses. Same discount for tinned. EXTRA per 100 lb. for 1½ to 2-in. long, all diameters, 25c.; ⅝-in. dia., 35c.; ½-in., dia., 75c.; 1-in. long and shorter, 75c.; longer than 5-in., 50c.; less than 200 lb., 50c.; countersunk heads, 45c.

Structural rivets, ¾, ⅞, 1 in. diameter by 2½ in. to 4½ in. sell as follows per 100 lb.:

New York $5.00* Chicago $3.50 Pittsburgh $2.50@2.60

Boiler rivets, same sizes:

New York $5.20* Chicago $3.70 Pittsburgh $2.90

* For immediate delivery from warehouse.

REFRACTORIES—Prices in car lots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$48@53
Chrome cement, 40@50% Cr_2O_3 in bulk	net ton	23@28
Chrome cement, 40@50% Cr_2O_3 in sacks	net ton	27@32
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	38@40
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	40@47
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	43@45
Clay brick, 1st quality, 9 in. shapes, Maryland	per M	48@50
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	33@40
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	40@43
Clay brick, 2nd quality, 9 in. shapes, Maryland	per M	43@45
Chrome ore crude, 40@50%	net ton	19.00@20.50

BABBITT METAL—Delivered, New York, cents per lb.:

Genuine, highest grade	81.50
Commercial genuine, intermediate grade	56.00
Anti-friction metal, general service	31.50
No. 4 babbitt (f.o.b.)	14.50

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.00	$3.90	$3.60
Flats and squares, per 100 lb. base	4.50	4.40	4.10

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13
LAP WELD					
2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			
BUTT WELD, EXTRA STRONG, PLAIN ENDS					
1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			
LAP WELD, EXTRA STRONG, PLAIN ENDS					
2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$17 07
1¼	.....	.....	19 20
1½	.....	$38 00	17 92
1¾	.....	28 50	20 48
2	$17 33	25 00	20 24
2¼	19 84	28 25	23 00
2½	21 60	34 00	26 03
3	25 50	42 50	27 04
3¼	30 25	49 50	30 67
3½	34 50	52 75	33 33
4	36.03	67.00	40.11

Tubes 2¼ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.
These prices are net per 100 ft. based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.
In addition to the above, standard cutting charges are as follows:
2 in. and smaller, 5c. per cut. 3 in., 9c. per cut
2¼ and 2½ in., 6c. per cut. 3½ to 4 in., 10c. per cut

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$34.50 (net)	$54.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	50%	20%
Coils to 1,000 ft.	55%	25%
1,000 to 5,000 ft.	60%	30%
5,000 ft. and over	60-5%	35%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$56 50	$61 34	$7 76	$8.83	$4.52	$4.92
⅜	72 07	78.63	10 21	11.63	6.46	7.03
1	103 31	113 00	15 10	17 21	8.39	9.13
1¼	139.77	152 88	20 51	23 07	11.78	12.75
1½	167 12	182 79	27 34	30 76	14 56	15.75
2	224 85	245 94	50 13	56 40	19 41	21 01
2½	355 50	388 85	82 03	92 28	27.73	30 01
3	464 88	508 50	218 74	246 10	41.59	45 01
3½	585 30	637 74	483 04	543 46	55 46	60 02
4	714 17	776 30	558.23	628.06	69.32	75.02

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG, SOLID NEUTRAL OR 2 FUSE

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE, SOLID NEUTRAL OR 2 FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy		$21.50
No. 16 cotton reinforced heavy		25.00
No. 18 cotton reinforced light		17.50
No. 16 cotton reinforced light		21.00
No. 18 cotton Canvasite cord		17 25
No. 16 cotton Canvasite cord		21.00
No. 16 super service cord or similar (2 wire) in 1,000 ft.	$92.00	*101.20
No. 14 super service cord or similar (2 wire) in 1,000 ft.	133.00	*146.40

*Less than 1,000 ft.

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	30	35-amp. to 60-amp.	100	.60
61-amp. to 100 amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 60%; 1-5th to standard package, 65%; standard package, 70%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP OR CLEARSITT—

0-30 ampere, standard package (500)	$2.85
0-30 ampere, less than standard package	3.15

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.27	$0.32	120	50	$0.40	$0.45	60
15	.27	.32	120	75	.45	.55	60
25	.27	.32	120	100	.50	.55	24
40	.27	.32	120	150	.65	.70	24
50	.27	.32	120	200	.80	.85	24
60	.32	.37	120	300	1.25	1.35	24
				500	2.00	2.15	12
				750	3.50	3.70	8
				1,000	3.75	3.95	8

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	08½

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$6.70	$9.75	$11.60	$18.20
12	10.10	12.60	14 60	23.80
10	13.20	16.40	18 60	30 50
8	19.00	22.30	24 20	42.40
6	.....	.....	34 40	.....
4	.....	.....	48 00	.....
2	.....	.....	68 75	.....
1	.....	.....	94 70	.....
0	.....	.....	115 00	.....
00	.....	.....	138 00	.....
000	.....	.....	165 00	.....
0000	.....	.....	196.00	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.36	$0.33	$0.50*	$0.42	$0.39	$0.56*

Less 1-5th standard package	30%
1-5th to standard package	40%
Standard package	45%

* Net.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 35c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 37c. lb., 100 lb. lots	35c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 to $50 list value	30-5%
$50 list value or over	35%